SPRINKLER IRRIGATION IN INDIA

इनसिड - INCID

भारतीय राष्ट्रीय सिंचाई एवं जल निकास समिति

(जल संसाधन मंत्रालय, भारत सरकार द्वारा गठित)

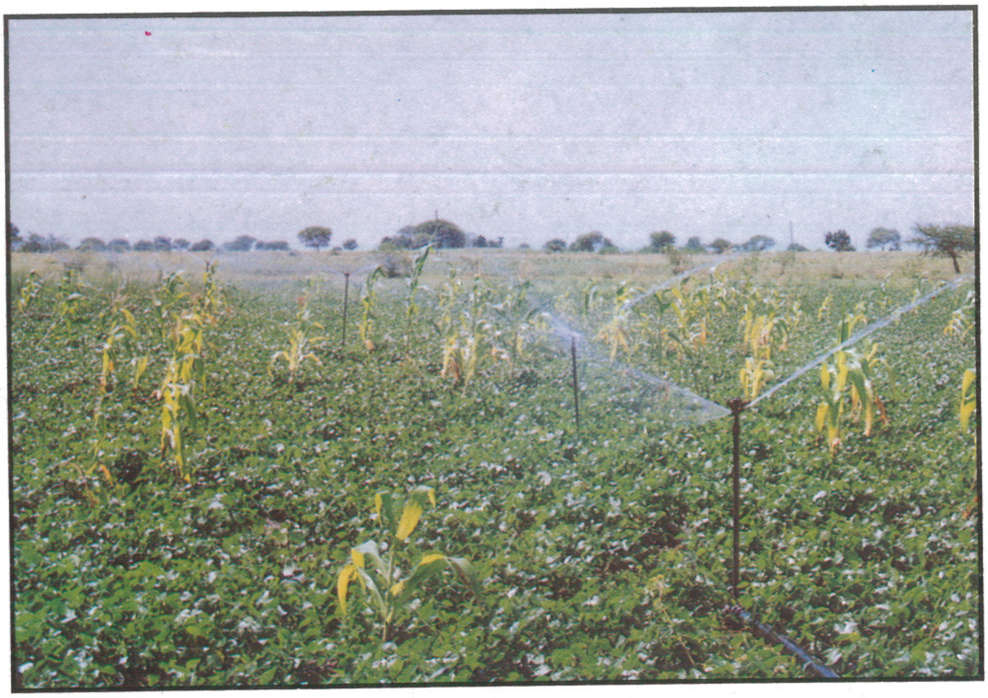
INDIAN NATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE

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

NEW DELHI

MAY, 1998

HDPE Sprinkler System for Cabbage
(Courtesy : Jain Irrigation)



Sprinkler Irrigation for Green Pea
(Courtesy : Jain Irrigation)

Front Cover : Sprinkler Nozzles
(Courtesy : Polyolefins Industries Ltd.)

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May, 1998

Printed at **Jolly Reprographics**, New Delhi - 110 008
Phone No. 5740443, 5744989, 5735796

Inner Page : Underground Sprinkler System for Landscapes/Lawns
(Courtesy : Polyolefins Industries Ltd.)

सत्यमेव जयते

MINISTER OF STATE
(INDEPENDENT CHARGE)
FOR WATER RESOURCES
GOVERNMENT OF INDIA
NEW DELHI 110001

November 18, 1997

FOREWORD

I am glad to know that the Indian National Committee on Irrigation and Drainage constituted by Ministry of Water Resources, Govt. of India is bringing out a comprehensive report on "Sprinkler Irrigation in India". The report is meant for wide circulation within the country and to all the National Committees of ICID globally.

Sprinkler Irrigation is an advanced method of irrigation which has higher water use efficiency as compared to conventional surface irrigation methods. It increases crop productivity by 15-25%. The saving in irrigation water by this method ranges from 10 to 55% depending upon agro-climatic conditions. All closely grown crops such as millets, pulses, gram, wheat, sugarcane, groundnut, cotton, vegetables and fruits, flowers, spices etc can be grown with Sprinkler Irrigation.

Due to the increase in demand for more water and to bring more areas under irrigation, the government as well as farmers are interested and eager to introduce Sprinkler Irrigation on a large scale. Especially in semi-arid regions with limited Water resources like some parts of Rajasthan, Haryana the introduction of sprinkler system has not only increased the area under irrigation but also the crop production per unit of Water. The Central and State Governments are providing incentives like loans and subsidies to the farmers for sprinkler Irrigation system. About 6.8 lakh hectares area is under Sprinkler Irrigation in India, which is very insignificant as compared to other developed countries and in the coming years we would have to increase the areas several folds under Sprinkler irrigation.

It is timely that the Indian National Committee on Irrigation and Drainage (INCID) is bringing out this status report on the subject. It is hoped that this document would provide the much needed impetus for rapid expansion of sprinkler irrigation in our country by serving as a hand book for planners, designers, implementation authorities, research organizations and above all to the farmers who are the end users. I congratulate the Indian National Committee on Irrigation and Drainage for bringing out such a useful publication of national importance during the 50th year of Independence.

(SIS RAM OLA)

भारतीय कृषि अनुसंधान संस्थान, नई दिल्ली-११० ०१२
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PREFACE

The rapid expansion of irrigation facilities since the first five year plan played a stellar role in increasing food production to meet the needs of the growing millions of the country's population. By March 1997, it is anticipated that a total of 90.2 m.ha of irrigation potential would be created. So far nearly 35% of the cultivated land is irrigated. It is estimated that about 325 m.t. of food grains are required to meet the needs of population by 2025 A.D. This calls for intensive efforts on the agricultural production front.

The net sown area has nearly reached a plateau at about 142 m.ha. The only way that the increase in food production has to come is through increased productivity of land through the use of high yielding varieties, improved inputs and irrigation. Improvements in water management technology can contribute substantially in this effort as water is essential to obtain the benefits from nutrients and other inputs of agriculture. Sustainability and productivity of the soil, and the maintenance of the environmental and ecological balance depend on efficient and economical use of the precious water resources.

Sprinkler 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 sprinkler 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. Sprinkler system is well suited for water scarcity areas and undulating topography where surface irrigation proves costly for land shaping and levelling.

Sprinkler irrigation was not familiar to the farming community in India till mid fifties. The plantation owners in the hills introduced sprinkler irrigation to irrigate tea, coffee and cardamom crops during dry season and dry spells of the monsoon period. In mid seventies, progressive farmers in Narmada valley in Madhya Pradesh, southern part of Haryana and north east part of Rajasthan started using sprinkler system to overcome problems of water shortage particularly during summer. Adoption of this system gradually spread to larger area in the states of Haryana, Rajasthan, Madhya Pradesh, Maharashtra and Karnataka.

The spread and popularisation of the sprinkler irrigation method with farmers has received significant support from the various schemes involving subsidy of the Central and State Governments in the recent years.

It is appropriate that the Indian National Committee on Irrigation and Drainage (INCID) is bringing out a status report on this important subject of sprinkler irrigation. I am happy that the Water Technology Centre, Indian Agricultural Research Institute has been actively involved in developing this report in close collaboration with the INCID.

I hope that all those engaged in the development and use of sprinkler irrigation will find this document useful.

R B Singh

(Prof. R.B. Singh)
Director, I.A.R.I.

PREAMBLE

Sprinkler Irrigation is an advanced method of Irrigation, by which water is sprayed through nozzles connected to a network of pipes with water supplied under pressure. This method of irrigation has higher application and distribution efficiency and affects considerable savings of water. Development of sprinkler Irrigation got a boost after the Second World War and there has been a tremendous development of it, particularly in Europe and in U.S.A. it serves nearly 45% of the Irrigated area. Sprinkler Irrigation in other countries of the world is under varying degrees of development.

Though, sprinkler irrigation technology was developed more than 75 years ago, elsewhere in the world, the use of sprinkler system in India was initiated in the mid fifties only for plantation crops like tea and coffee. Area under sprinkler method of irrigation in India is too low compared to many other countries. Though detailed and accurate statistics are not available, it is estimated that the total area under sprinkler irrigation in India is about 0.66 m ha of the total irrigated area of 87.80 m ha in 1995 which is less than 1% of the irrigated area. All out efforts will have to be made during the coming years to cover more and more areas under Sprinkler Irrigation say going upto at least 10% of the irrigated area.

The Ministry of Agriculture, Government of India and different State Governments have been providing subsidy support to propagate the Sprinkler Irrigation with a view to encourage second green revolution.

The Indian National Committee on Irrigation and Drainage (INCID) sought the assistance of Dr R.K. Sivanappan, former Dean, Tamil Nadu Agricultural University, Coimbatore and a member of INCID Special Committee on Micro and Mechanized Irrigation for providing the draft for the Status Report. The draft report was widely circulated to all members of Special Committee, INCID members, all Central and State Organisations, related experts for their comments/views and suggestions. Later on, the draft report alongwith the Compendium of comments/suggestions received from the various organisations was discussed in a National Seminar in December, 1995. The Seminar was inaugurated by Hon'ble Union Minister of State for Water Resources and attended by the Secretary, Ministry of Water Resources, Chairman, INCID & CWC, Members of INCID and its Special Committee, Central and State Organisations, ICID Central Office, Manufacturers of Sprinkler Systems, NGOs, etc.

As decided in the Seminar, the draft report was then referred for review and modifications to a Working Group consisting of a select group of seven experts drawn from Water Technology Centre, IARI, Central Water Commission, State Governments, Research Institutes and INCID Secretariat. The Working Group headed by Dr P.B.S. Sarma, Project Director, Water Technology Centre reviewed the draft report (all Chapters) and suggested extensive modifications and updating in various Chapters. As per the recommendations of the Working Group, the modified draft was edited by a small

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ABBREVIATIONS

B.C.Ratio	:	Benefit Cost Ratio
BIS	:	Bureau of Indian Standard
CCA	:	Catchment Command Area
CGWB	:	Central Ground Water Board
CWC	:	Central Water Commission
DIS	:	Drip Irrigation System
FRP	:	Fibre Reinforced Plastic
GBPUAT	:	Govind Ballabh Pant University of Agriculture & Technology
GCA	:	Gross Cropped Area
GIA	:	Gross Irrigated Area
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
Kmph	:	Kilometer per hour
LDPE	:	Low Density Polyethylene
LLDPE	:	Linear Low Density Polyethylene
Lph	:	Litres per hour
Lps	:	Litres per second
MCU	:	Master Control Unit
M.ha.	:	Million hectare
M.ha.m.	:	Million hectare metre
M&M	:	Major and Medium
MOWR	:	Ministry of Water Resources
NGOs	:	Non-Governmental Organisations
Na	:	Sodium
O&M Cost	:	Operation and maintenance Cost
PDC	:	Plasticulture Development Centre
q/ha	:	Quintal/hectare
SIS	:	Sprinkler Irrigation System
T/ha	:	Tonnes/hectare
UTs	:	Union Territories
WALMI	:	Water and Land Management Institute
WAPCOS	:	Water and Power Consultancy Services (India) Limited
WTC	:	Water Technology Centre
WUE	:	Water Use Efficiency

SPRINKLER IRRIGATION IN INDIA

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CHAPTER 1

INTRODUCTION

Extensive development of irrigation facilities in India since the first Five Year Plan, contributed substantially to the increased food production. However, unscientific and inefficient use of irrigation water in several areas, led to undesirable effects threatening long term sustainability of agricultural production. Further, in the context of opening of India's economy to international markets, a major shift of investments from industry to agriculture is anticipated in the coming years. As such, the efficiency with which water is used in agriculture determines the extent to which agricultural sector can benefit from the changing economic scenario. Thus efficient use of water by adopting modern techniques such as sprinkler irrigation becomes important. A brief review of the status of India's water resources and their utilisation so far, and the need for efficient water use is presented in this chapter.

1.1 WATER RESOURCES OF INDIA

The water resources of India can be grouped as rivers and canals, reservoirs, lakes and tanks, ground water and soil water.

Rainfall : Rainfall is the major source of water over the country. A limited quantity of snow occurs in the northern parts of India. The rainfall over India is characterised by wide spatial and temporal variations. The annual rainfall varies from a mere 311 mm in western Rajasthan to over 11400 mm in Meghalaya with an average value of 1195 mm for the entire country. More than 73 percent of this rainfall occurs during 4 to 5 months of monsoon (June-October). About 70 percent of the geographical area of the country experiences annual rainfall of 750 mm or more.

River flows : The annual precipitation including snow fall, occurring over the geographical area of 329 m.ha of the country amounts to 4000 km^3. This generates runoff from 12 major river basins (catchment area greater than 2 m.ha) and 48 medium river basins (catchment area between 0.2 and 2 m.ha). The total annual surface flow is estimated to be 1880 km^3. The identified utilisable surface water resources are 690 km^3.

Storages and tanks : The total live storage created in India during the last 40 years is about 226 km^3 which is a mere 12 per cent of the average annual flow of 1880 km^3. The estimated ultimate storage potential is 510 km^3. A comparison to the situation in USA is in order where the average annual runoff of 1700 km^3 is comparable to that of India. The storage capacity created in USA during the past 40 years is

Table 1.1
Statewise surface water availability and use in agriculture Major & Medium Irrigation (1992-93)

(Thousand Hectares)

Sl.No.	State/UTs.	Ultimate potential	Annual Plan 1992-93	
			Potential Created	Potential Utilised
1	2	3	4	5
1.	Andhra Pradesh	5000	3005	2850
2.	Arunachal Pradesh	-	-	-
3.	Assam	970	182	114
4.	Bihar	6500	2770	2300
5.	Goa	-	13	12
6.	Gujarat	3000	1275	1058
7.	Haryana	3000	2047	1803
8.	Himachal Pradesh	50	8	4
9.	Jammu & Kashmir	250	172	140
10.	Karnataka	2500	1421	1209
11.	Kerala	1000	429	379
12.	Madhya Pradesh	6000	2032	1434
13.	Maharashtra	4100	2076	1036
14.	Manipur	135	62	53
15.	Meghalaya	20	-	-
16.	Mizoram	-	-	-
17.	Nagaland	10	-	-
18.	Orissa	3600	1427	1349
19.	Punjab	3000	2382	2324
20.	Rajasthan	2750	2043	1900
21.	Sikkim	20	-	-
22.	Tamil Nadu	1500	1545	1545
23.	Tripura	100	2	2
24.	Uttar Pradesh	12500	6860	5828
25.	West Bengal	2310	1362	1269
	Total States	58315	31113	26609
	Total UTs.	160	15	7
	All India Total	58475	31128	26616

Source:- Central Water Commission (P&P Directorate).

1054 km^3, which is four times that of India. Thus, the role of water resources development and storage in reducing the vulnerability of the agriculture to the vagaries of weather is of utmost importance for sustainable production.

Inter basin transfers : There are several river basins in India where the water resources are excessively surplus and give rise to problems of floods and continued submergence of crops. At the same time there are other river basins where the available water resource is too small. Technically, it is feasible to link such water deficit areas with water surplus areas and affect inter basin transfer of water to increase the utilisable component of the nation's water resources. It is estimated that about 25 m.ha. of cropped area can be brought under irrigation through inter basin transfer of water.

Groundwater : Groundwater is a naturally occurring renewable resource. The total annual replenishable and utilisable ground water resource is estimated to be 431.8 Km^3. The ground water resource available for irrigation is estimated as 360.8 km^3 after setting aside the balance for domestic and industrial uses. The Ultimate irrigation potential from groundwater is estimated as 64.04 m.ha. Details of statewise surface (M & M), Surface (Minor irrigation) and ground water resources availability and their use in agriculture so far, are given in Tables 1.1, 1.2 and 1.3 respectively.

1.2 WATER UTILISATION PATTERN

The estimated use of water in agriculture, domestic and industrial and other uses by 1990, 2000 and 2025 A.D. are given in Table 1.4. It is seen from Table 1.4., agriculture is the major user of water. It is estimated that percentage availability of water to agriculture will be drastically reduced in coming years and severe water shortages are likely to be experienced beyond 2025 A.D.

1.3 DEVELOPMENT OF IRRIGATION IN INDIA

The rapid expansion of irrigation facilities since the beginning of the first five year plan (1950-51) played a stellar role in increasing food production to meet the needs of the growing millions of the country's population. By March 1997, it is anticipated that a total of 96.9 m.ha of irrigation potential would be created. So far nearly 35% of the cultivated land is irrigated.

Table 1.2
Statewise Surface Water (Minor Irrigation) Availability and Use in Agrilculture (1992-93)

(Thousand Hectares)

Sl.No.	State/UTs.	Ultimate potential	Annual Plan 1992-93	
			Potential Created	Potential Utilised
1	2	3	4	5
1.	Andhra Pradesh	2300.0	1292.5	1113.4
2.	Arunachal Pradesh	150.0	66.0	57.0
3.	Assam	1000.0	403.0	344.2
4.	Bihar	1900.0	1369.9	1225.2
5.	Goa	25.0	17.1	15.5
6.	Gujarat	347.0	198.3	159.2
7.	Haryana	50.0	39.0	34.0
8.	Himachal Pradesh	235.0	128.9	112.8
9.	Jammu & Kashmir	400.0	357.4	345.0
10.	Karnataka	900.0	728.2	704.3
11.	Kerala	800.0	419.3	398.2
12.	Madhya Pradesh	2200.0	1100.9	949.9
13.	Maharashtra	1200.0	907.0	705.7
14.	Manipur	100.0	50.9	41.8
15.	Meghalaya	85.0	35.9	30.0
16.	Mizoram	70.0	11.0	9.3
17.	Nagaland	75.0	65.0	55.8
18.	Orissa	1000.0	649.1	575.7
19.	Punjab	50.0	45.6	43.7
20.	Rajasthan	600.0	444.4	403.5
21.	Sikkim	50.0	22.9	17.7
22.	Tamil Nadu	1200.0	862.7	862.4
23.	Tripura	100.0	72.3	64.5
24.	Uttar Pradesh	1200.0	1044.0	980.0
25.	West Bengal	1300.0	1266.7	1138.4
	Total States	17337.0	11597.9	10387.2
	Total UTs.	41.0	21.2	17.3
	All India Total	17378.0	11619.1	10404.5

Source:- Water and Related Statistics, Central Water Commission, 1996.

Table 1.3

Statewise groundwater (Minor Irrigation) potential and utilisation in agriculture (1993)

Sl. No.	States	Ultimate Potential from Ground water Resource (m.ha)	Irrigation potential created (m.ha)
1.	Andhra Pradesh	3.9601	1.9290
2.	Arunachal Pradesh	0.0180	0.0021
3.	Assam	0.9000	0.1800
4.	Bihar	4.9476	1.4276
5.	Goa	0.0293	0.0017
6.	Gujarat	2.7559	1.8406
7.	Haryana	1.4616	1.5879
8.	Himachal Pradesh	0.0685	0.0153
9.	Jammu & Kashmir	0.7080	0.0120
10.	Karnataka	2.5738	0.7284
11.	Kerala	0.8792	0.1572
12.	Madhya Pradesh	9.7325	1.8743
13.	Maharashtra	3.6520	1.2901
14.	Manipur	0.3690	0.0004
15.	Meghalaya	0.0635	0.0092
16.	Orissa	4.2026	0.3931
17.	Punjab	2.9171	5.1170
18.	Rajasthan	1.7779	1.5052
19.	Tamil Nadu	2.8321	1.9631
20.	Tripura	0.0806	0.0199
21.	Uttar Pradesh	16.7990	14.000
22.	West Bengal	3.3179	1.3203
	Total States	64.0452	35.3753
UNION TERRITORIES			
1.	Dadar & N. Haveli	0.0051	0.0008
	Total UTs.	0.0051	0.0008
	Grand Total	64.0503	35.3761

Source :- Ground Water Statistics, Central Groundwater Board

Table 1.4
Estimates of Water needs (M.ha. m.)

ACTIVITY	YEARS					
	1990	%	2000	%	2025	%
Irrigation	46.0	83.4	63.0	84.4	77.0	73.3
Domestic	2.5	4.5	3.3	4.4	5.2	5.0
Industrial	1.5	2.7	2.7	3.6	12.0	11.4
Energy	1.9	3.4	2.7	3.6	7.1	6.8
Others	3.3	6.0	3.0	4.0	3.7	3.5
Total	55.2	100	75.0	100	105.0	100

Source : Shri K.N.Prasad and Shri P.B.Parabrahamam,
Second National Water Convention, 15-17 September, 1990, Hyderabad

The ultimate irrigation potential of the country is estimated to be 139.9 m.ha which includes 58.5 m.ha from major and medium irrigation (CCA > 2000 ha) projects, 81.4 m.ha from minor (Surface Water - 17.38 m.ha : Ground Water - 64.05 m.ha.). If inter-basin transfer component is also taken into account, the ultimate irrigation potential would be 164.9 m.ha. The Govt.of India laid special emphasis on speedy development of irrigation potential through its various annual and five year plans. By 1995 the total irrigation potential created was 87.8 m.ha. By the end of the eighth five year plan, (March 97), it is anticipated that a total of 90.2 m.ha of irrigation potential would be created. Of this, major and medium irrigation projects are expected to contribute about 30.6 m.ha (about 158 major and 226 medium schemes) while minor irrigation schemes including groundwater and surface water schemes account for 59.6 m.ha. Of this, the irrigation potential created from ground water alone would be 48.1 m.ha.

The projected values for 1992-93, 2000 AD and 2025 AD of cropped area, intensity of cropping and irrigated area are given in Table 1.5.

Table 1.5
Cropped area, cropping intensity and Irrigated area

Year	Net cropped area m.ha	Cropping intensity %	Gross cropped area m.ha	Gross irrigated area m.ha	% of GIA* to GCA**
1	2	3	4	5	6
1992-93	142.5	130.2	185.5	66.1	35.6
2000 AD	150.0	133.0	200.0	84.0	42.0
2025 AD	155.0	136.0	210.0	110.0	52.0

Source : (i) Report of National Commission on Agriculture(1976)
(ii) Directorate of Economics & Statistics Ministry of Agriculture, New Delhi (1996).
*GIA : Gross Irrigated Area; **GCA: Gross Cropped Area

It is estimated that 240 and 325 million tonnes of food grains will be required to meet the needs of population by the years 2000 and 2025 AD respectively. The progressive development of irrigation potential and its impact on the food grain production over the past 45 years is shown in Figures 1.1 & 1.2.

It may be noted from these figures that of late, the rate of expansion of irrigation facilities as well as that of food grain production has decreased. This is indicative of limitations on the natural as well as financial resources. The cost of irrigation development has raised steeply from mere Rs. 1500/ha in 1950-51 to as high as Rs.65,700/ha in 1995. It is to be noted that although the irrigation potential was developed at a huge cost and considerable effort, a large gap exists between the irrigation potential created and utilized. By the end of the eighth Five Year Plan (1997) this gap would be as much as 10.42 m.ha of which 5.26 m.ha is from major and medium irrigation projects, the rest 5.16 m.ha being from minor irrigation schemes.

1.4 NEED FOR ECONOMIC USE OF WATER

The net sown area has nearly reached a plateau at about 142 m.ha. after having exhausted most of the arable land. The only way that the increased food production has to come is through increased productivity of land through the use of high yielding varieties, improved inputs and irrigation. Further, due to unscientific practices of crop water management, parts of the irrigated areas have become waterlogged and are afflicted by soil salinity problem leading to reduction in productivity of the lands. The improvements in water management technology can contribute substantially in this effort as water is essential to obtain the benefits from nutrients and other inputs of agriculture. Thus sustainability and productivity of the soil and the maintenance of the environmental and ecological balance depend on efficient and economical use of the precious water resources.

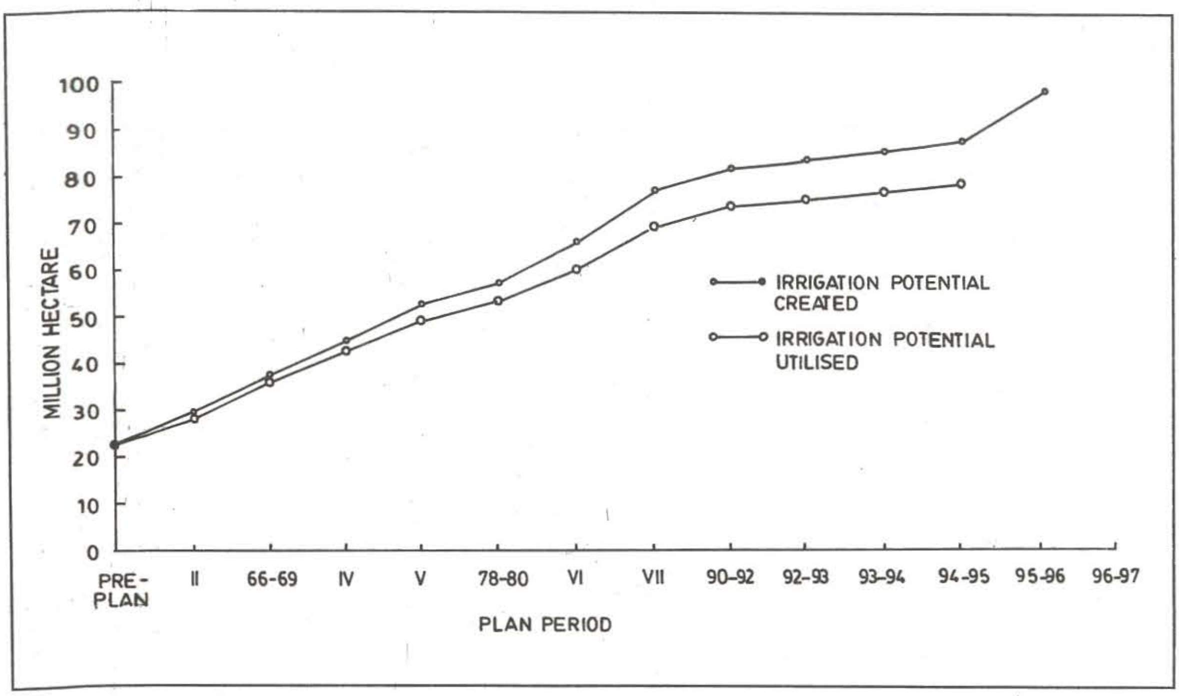


Fig. 1.1. Progressive Development of Irrigation Protential in India

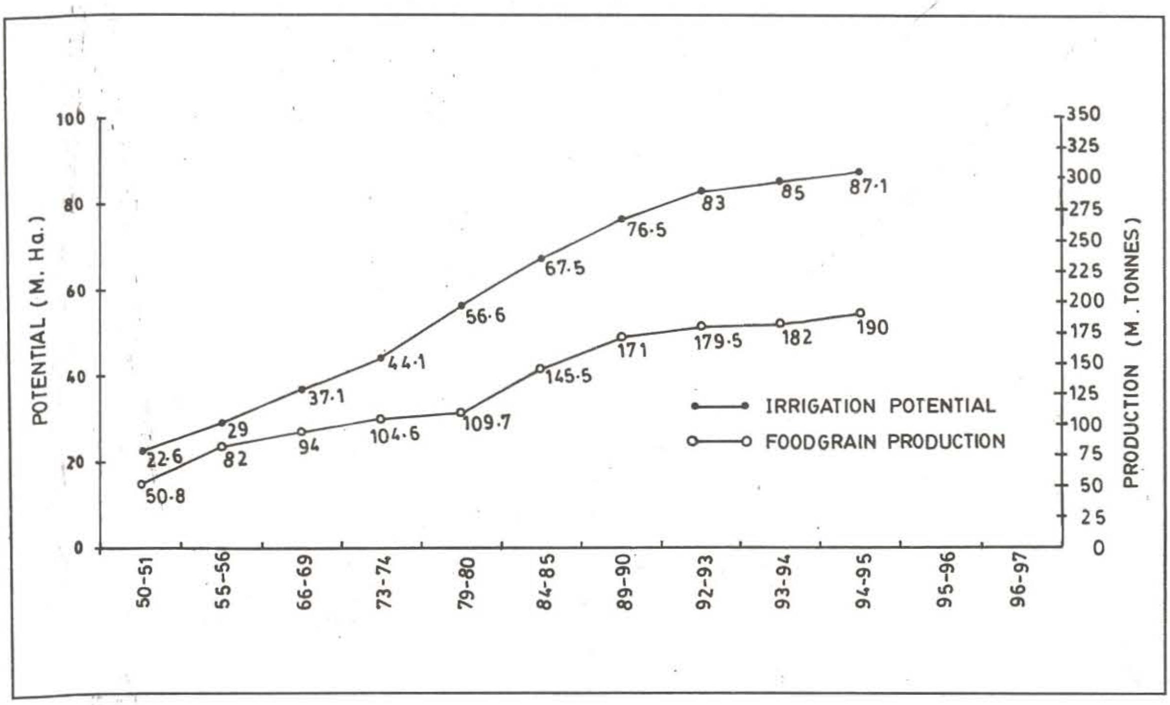


Fig. 1.2. Progressive of Irrigation Protential and Foodgrain Production in India

The overall efficiency in irrigation projects in India is rather too low at an average of 25% in the case of major and medium irrigation projects. In most irrigation project areas, the following draw backs are invariably noticed:

i) The traditional irrigation systems were designed mainly for protective irrigation and not productive irrigation,
ii) The system can not meet the requirement of the modern intensive agriculture based on high yielding crop varieties and multiple cropping with increased fertilizer use,
iii) Soil - water - plant environmental interactions are not normally reflected either in planning , design or operation.
iv) Water balance in the irrigated area is not considered nor the impact of irrigation on the ground water conditions ever studied at planning stage,
v) Unscientific water management practices due to inadequate drainage, improper water application, non matching of irrigation supplies and requirements etc.; and
vi) Inappropriate water charges that are not conducive to economic and efficient use of irrigation water.

Most of these problems arose due to inadequate adoption of scientific approach. In general, Very little effort was made to adopt efficient water distribution and application methods. Added to these draw backs, the major and medium irrigation project areas also suffer from wide variations in soils, climate and cropping activity, across the length and breadth of the command area. Thus the huge scale of operations and lack of compatible mechanism of efficient operation contribute to low levels of operational efficiencies of major and medium irrigation projects in India. However, the irrigation efficiency in the case of minor irrigation projects is relatively higher. The investments in irrigation sector increased manifold since 1950-51 from Rs.5.06 Billion to Rs.23.0 Billion per year (at constant prices 1980-81=100) as shown in Fig. 1.3. Inspite of such huge investments, the increase in food production is not commensurate with the investments. The average productivity of irrigated land is about 2.0 t/ha while in selected locations it is proved to be much higher, upto 10 t/ha. Thus there is an immense need for improving the efficiency in using irrigation water. Besides the proven improved levels of efficiency of the furrow and surge methods of irrigation, there is still a need for development of suitable technologies for improved methods of irrigation. The modern methods of irrigation such as drip and sprinkler methods provide answer to this problem. Essentially, these methods do not involve significant conveyance and percolation losses, besides providing good control on water application. Thus these methods perform far better than the traditional surface irrigation methods.

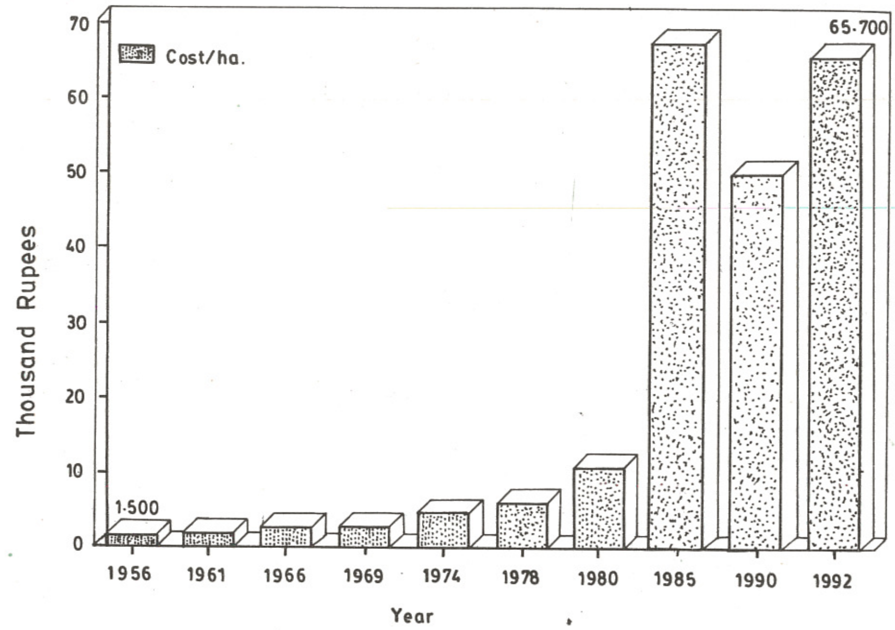


Fig 1.3 Cost of irrigation (M & M) per hectare.

1.5 SPRINKLER IRRIGATION METHOD

In the sprinkler irrigation method of irrigation, water is sprayed through nozzles connected to a network of pipes with water supplied under pressure. The rate of spray of water can be regulated and natural rainfall can be simulated. This method has higher application and distribution efficiency and affects considerable savings of water, and provides complete control on timing and quantity of irrigation water to be applied. The over all efficiency of sprinkler method is as high as 65% compared to 25-30% of surface method of irrigation. Just enough water to adequately wet the root zone of the water can be applied and thus avoiding wastage of water through percolation. As the water is conveyed through closed pipe system, conveyance losses are the least in sprinkler method of irrigation. As the time of application of water can be controlled effectively, light and frequent irrigations can be applied and a healthy moisture regime can be maintained in the root zone of the crop thus leading to healthy crops and higher levels of production of good quality produce. Further, this method leads to considerable savings in the irrigation water and thus leads to increase in the area that can be served and hence higher irrigation intensity and agricultural production in general. Inspite of these advantages, as of 1995, only less than 1% of the cropped area in the country is brought under this method of irrigation. Initial capital cost, lack of expertise in its operation and maintenance have limited the use of this system to plantation crops in hilly areas. This technology being gradually adopted in other situations also, particularly in water scarce areas and in the case of high value export oriented commercial crops like flowers, vegetables and horticultural crops. The Government of India is also responding to the situation by providing certain subsidies to farmers to encourage the adoption of this efficient irrigation system.

CHAPTER 2

IRRIGATION PRACTICES

Irrigation implies application of water to crops in right amounts at right times. The method of irrigation depends upon many factors such as topography of the land, hydro-physical and chemical characteristics of the soil, types of crops grown, quality and quantity of water available, the nature and availability of inputs like nutrients and labour, economic status and preference of the farmers etc. Though the science of irrigation has developed greatly in the last 30-40 years in India with reference to soil, water-plant-atmospheric inter-relationships, water requirements of crops and scheduling of irrigation, it is not widely adopted in practice in the country.

2.1 GRAVITY METHODS OF IRRIGATION

From the time immemorial, gravity irrigation methods have been followed in India and elsewhere in the world. The different types of gravity irrigation are uncontrolled flooding, border irrigation, check basin, and furrow methods. By and large, the quantity of water applied by these methods are based on its availability and not particularly tuned to meet the requirements of crops. Further, a large part of the irrigation water is lost in conveyance through seepage and leakages. In major and medium irrigation projects, only less than 50% of the water released from the storage reservoir reaches the plants. Further losses also occur due to factors such as poor land grading, inadequate land preparation, improper on-farm water distribution and lack of farmer's know-how of efficient ways of application of irrigation water.

Higher efficiencies in gravity irrigation can be obtained under certain controlled conditions, such as in a research station or in projects managed and operated by trained, highly-skilled personnel. These skills include; i) planning and execution of land-forming operations including leveling, ii) introduction of advanced techniques in the determination of irrigation frequencies, quantities, stream size and duration of irrigation, the installation and operation of water measurement and regulation systems, iii) adaptation of surface irrigation technique to cropping patterns and iv) provision of drainage systems for the removal of excess water.

In practice, gravity irrigation has the following disadvantages:

a. Cumbersome and time-consuming surveying, levelling and land shaping cause temporary reduction in soil fertility.

b. Possibility of accumulation of water, causing water logging and salinity, particularly if drainage facilities are inadequate.

c. Large quantity of water is needed per unit area as small quantities of water are almost impossible to apply.

d. The crop root zone is subject to frequent alternate wetting and drying.

e. Need for care in water applications and continuous vigilance.

However, the advantage in using gravity irrigation is its comparatively low initial capital cost as well as nominal O&M costs.

2.2 IMPROVED METHODS OF IRRIGATION

A salient feature of any improved method of irrigation is the controlled application of the required amount of water at desired times, which leads to minimisation of range of variation of the moisture content in the root zone thus reducing the stress on the plants. The sprinkler and drip methods of irrigation meet this requirement adequately.

2.2.1 Sprinkler Irrigation

Sprinkler irrigation is an irrigation system that sprinkles water in a manner similar to rainfall, such that the run off and deep percolation losses are avoided and the uniformity of application is close to that obtained under rainfall conditions. In this system, water is conveyed through a network of pipes, called mains and laterals, under high pressure and is forced through nozzles of small diameter. Thus, the conveyance losses are eliminated in this method of irrigation, resulting in higher irrigation efficiencies. The sprinkler method of irrigation could be introduced for a large number of crops depending upon the soil, slope, water resource, farmers capacity for investment etc. The yields of the crops are high under this method of irrigation. Further, considerable saving of water is also affected. The reasons attributed for increased yields are:

i) Water is applied once in 3 to 4 days period in sprinkler irrigation which reduces the moisture stress to plants to considerable extent.

ii) The water application is controlled and only the required amount of needed water can be applied by this system.

The moisture distribution patterns in the root zone for various methods of irrigation are shown in Fig.2.1. In sprinkler method, irrigation is given under controlled conditions just enough to wet upto the root depth and it is possible to give the required quantity at the required time. The savings of water upto 30 to 50% are reported in the literature. Hence, by introducing this method for closely spaced high value crops, upto 50% additional area can be brought under irrigation besides increased yields. The system is capable of providing different application rates and diameter coverage. This method can be used to irrigate a wide variaty of crops except paddy and jute.

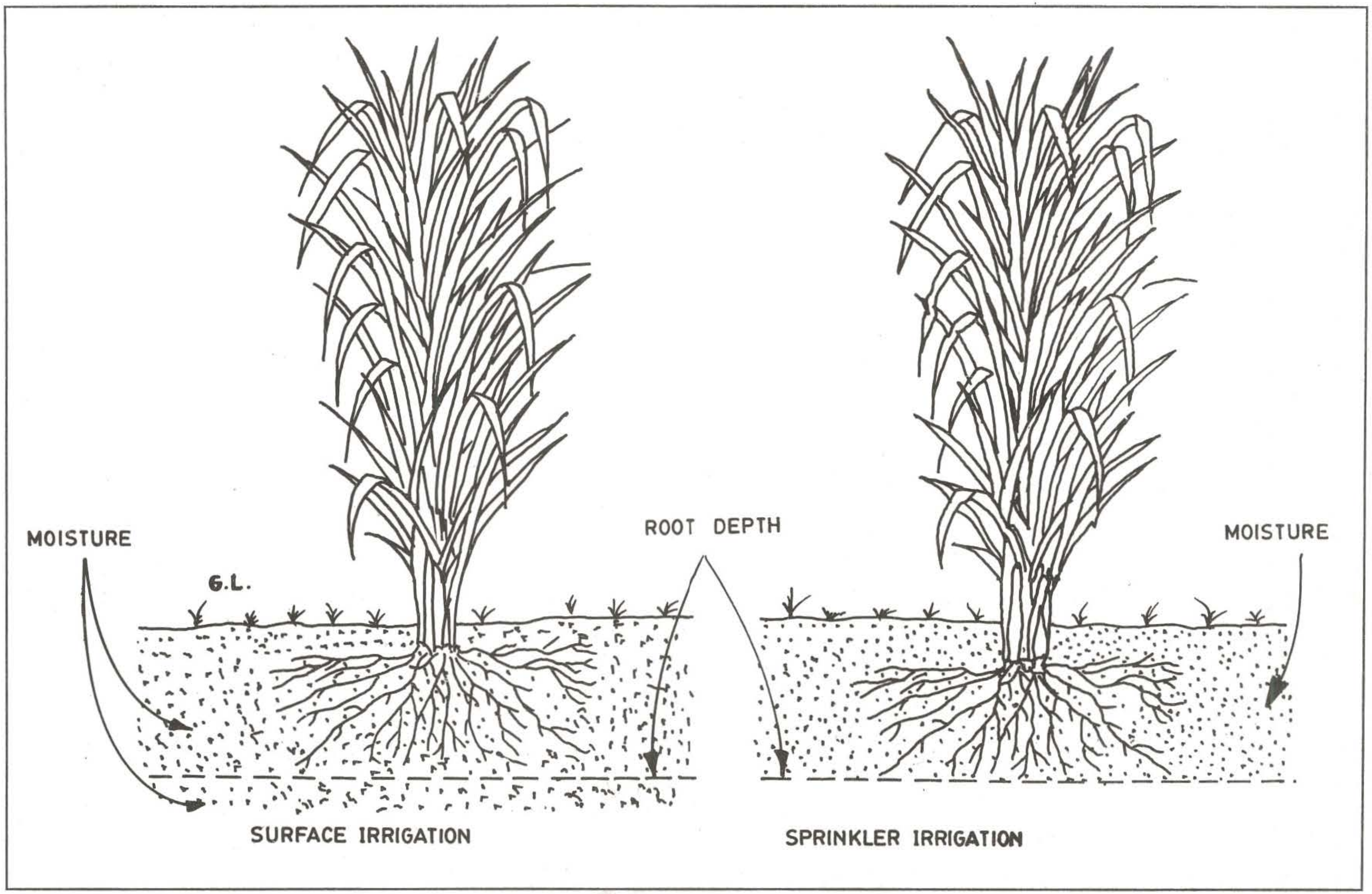


Fig. 2.1 Moisture distribution pattern in the root zone for flood and sprinkler irrigation.

The sprinkler method of irrigation is fast replacing the traditional gravity irrigation methods in all developed countries due to higher efficiencies of water use and application, less labour requirement, adoptability to hilly terrain, suitability for water scarce areas, ability to reduce frost attack and possibility to apply water soluble fertilisers.

2.2.2 Drip Irrigation

This method is well suited for wide spaced high value crops like coconut, grapes, banana, lime, etc. 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 application. 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. Research Studies have indicated that the water saving is about 40-70% and yield is increased by 10-100% for various crops, if the drip method is used. INCID has already published a Report on "Drip Irrigation in India" (July, 1994) which can be referred for more details on "Drip Irrigation" techniques, its development, design of drip irrigation system, research in drip irrigation, benefit cost and economics, potential prospects and perspective of drip irrigation etc.

2.2.3 Micro Sprinkler Irrigation

The micro sprinkler method of irrigation has the advantages of both the sprinkler and drip irrigation methods. Water is sprinkled or sprayed around the root zone of the trees with small sprinklers that work under low pressure. This unit is fixed in a network of tubing but can be shifted from place to place around the area. The required exact quantity of water can be delivered to each plant daily at the root zone. Water is given only to the root zone area as in the case of drip irrigation unlike to the entire ground surface as in case of sprinkler irrigation method. This method is highly suitable for tree/orchard crops and vegetable crops.

New irrigation technologies are being developed in various universities and research organisations in India and some of these are tried on large scale on farmers' fields and for situations where controlled application of exact amount of irrigation water, as in the commercial farms, is needed. For instance, plasticulture, i.e., use of plastics for agriculture including for irrigation is accepted by farmers. Thus, these modern methods of irrigation like drip, sprinkler and micro sprinkler irrigation are not necessarily limited to undulating terrain only, but are extremely useful in water scarce areas.

2.3 NEED FOR SHIFT IN APPROACH TO IRRIGATION

The present practice of harvesting and utilisation of the water is by constructing big dams and store large quantity of water in the reservoirs and take this water through a network of canals upto outlets (sluice) to irrigate about 10-40 ha under each outlet.

Experience has shown that the overall water use efficiency in the major and medium irrigation projects is less than 30%. This is due to the fact that the water is conveyed through uncontrolled gravity flow and the farmers use as much water as possible oblivious of the ill effects of over irrigation including leaching of fertilizers, unequal distribution of water, water logging in low lying area, and land becoming saline in due course. The result is poor yields and lands becoming unproductive after some years. This situation is noticed in several irrigation projects in India. This is due to the several factors listed in Chapter 1.

The immediate need of the hour for increased production of food grains on a sustained basis is to bring more area under improved irrigation methods using the same quantity of water and causing least environmental problems. This calls for a change in the concepts of irrigation and the traditional irrigation (flooding) methods need to be replaced by more efficient methods, that can be adopted by farmers with some training.

Irrigation science and technology have developed in a rapid way in the last 30 years especially in conveyance and distribution and application of water. Large quantity of water can be conveyed through large diameter pipes with practically no transmission losses. Water could be applied in specified quantities and intervals to match the water requirements of the crops, directly to the root zone of plants. Soluble fertilisers can also be applied alongwith water. The problems of drainage, undesirable leaching of nutrients and associated problems of waterlogging and salinity build up can be practically eliminated.

With the advances made in irrigation science, soil science, atmospheric and crop sciences, knowledge of better water management practices based on soil, water, plant, atmospheric relationships are now available for most crops.

By introducing pipe conveyance system clubbed with sprinkler and drip irrigation for the crop, it is possible to expand irrigation facilities to larger area from the same quantity of water. The conveyance of water through pipes coupled with the use of pressurized irrigation methods is practiced in many countries. Development in this direction has already started in the water scarce states in India such as Gujarat and Maharashtra. Maharashtra Government sanctions lift irrigation schemes only if the water is conveyed through pipes and use drip or sprinkler method of irrigation. The Gujarat Government is planning to bring large area under irrigation by introducing drip method in the Narmada Project (Sardar Savovar Project). The Governments of Madhya Pradesh and Haryana have introduced sprinkler method in the canal command area to increase the water use efficiency. To meet the nation's need of food grains to satisfy the people's aspirations and for a sustained and increased production, there is no alternative but introducing the advanced technologies of irrigation in the coming years for agricultural development in the country. By adopting these technologies it is possible to bring a major part of the cultivable land under irrigation in the country. But the main constraints are :

a. The present cost of the system is too high.
b. Trained manpower is needed for installation, operation and maintenance.
c. The indigenous production is inadequate to meet the demand.

The Government of India, has recently adopted a subsidy policy that took care of the first and the major constraint. Efforts need to be stepped up to mitigate the other constraints also.

CHAPTER 3

SPRINKLER IRRIGATION

Though, the sprinkler irrigation technology was developed more than 75 years ago, elsewhere in the world, the use of sprinkler systems in India was initiated only in the mid fifties for plantation crops like tea and coffee. Due to the increasing demands for water and the need to bring more and more area under irrigation, the Government and farmers are interested in introducing sprinkler irrigation system on a large scale to other crops also.

3.1 HISTORICAL DEVELOPMENT

Development of sprinkler irrigation got a boost mainly after the Second World War with the introduction of light-weight, portable aluminium pipes. At the same time, improved sprinklers and quick couplers, that facilitated convenient uncoupling and recoupling of pipes, became available and hence, there has been a remarkable development. The area irrigated by sprinkler system is 8.57 m.ha. in USA by 1991. Although sprinklers are becoming increasingly popular all over the world, irrigation is still carried out predominantly by gravity methods.

Sprinkler irrigation in other countries is under varying degrees of development and for different purposes of utilization. Bulgaria irrigates 0.496 million hectares area and accounts for 50% irrigated area, Saudi Arabia irrigates 1.03 million ha. area and accounts for 64% of total irrigated area. In U.K. 90% of total area is irrigated through sprinkler irrigation system. In Zimbabwe, sprinkler irrigation system accounts for 70% of its irrigated area. Number of installations were made in Tunisia, Libya, Turkey and other countries also. Sprinkler units were installed in Taiwan in 1952 for irrigating sugarcane crop with encouraging results. In Italy and Greece, sprinkler irrigation is widely adopted. Australia has introduced sprinkler on a large scale for orchards and fodder crops in about 46,000 ha. By 1990 the total area under sprinkler irrigation in the world was about 21.58 m.ha. This is significant because it was accomplished almost entirely by individual farmers with their own financial resources. The details of area under sprinkler irrigation system in different countries in the world are given in Table 3.1.

3.2 DEVELOPMENT OF SPRINKLER IRRIGATION IN INDIA

Sprinkler irrigation was not familiar to the farming community in India till mid fifties. Area under sprinkler method of irrigation in India is too low compared to many other

Table 3.1
Country-wise Area under Sprinkler Irrigation Systems

Sl. No.	Country	Year	Area Under Sprinkler Irrigation (ha)	Remarks
1.	Afghanistan	1967	1,14,000	
2.	Algeria	1994	40,000	
3.	Angola	1980	11,445	
4.	Australia	1980	10,970	South Australia
5.	Austria	1980	46,000	
6.	Bahrain	1994	130	
7.	Belgium	1980		Sprinklers used for flowers, garden and nursery.
8.	Benin	1994	4,470	
9.	Botswana	1992	892	
10.	Brazil	1980		Use started in 1950, mainly for coffee plantations.
11.	Bulgaria	1980	4,96,000	Around 50% area.
12.	Burkana Faso	1992	3,900	humid area.
13.	Canada	1980	65,000	Alberta, British Colombia, humid area
14.	Chile	1980		Small extent, to protect the crop from frost.
15.	China	1980		
16.	Congo	1993	111	
17.	Cyprus	1980	6,690	
18.	Czechoslovakia	1980	45,207	
19.	Denmark	1980	2,95,000	
20.	Ecuador	1980	16,000	
21.	Egypt	1993	3,13,000	
22.	Germany (Democratic Republic)	1980	4,37,000	
23.	Germany (Federal Republic)	1980		Sprinkle for anti-freeze irrigation works
24.	Ghana	1994	580	
25.	Greece	1980	3,80,000	
26.	Guinea	1994	1,594	

Sl. No.	Country	Year	Area Under Sprinkler Irrigation (ha)	Remarks
27.	Hungary	1980	3,33,802	
28.	France	1980	6,00,000	
29.	India	1995	6,58,000	
30.	Iran	1993	47,200	
31.	Italy	1980	5,17,000	17% of irrigated area
32.	Japan	1980		Upland area irrigated by sprinklers
33.	Jordan	1991	5,700	
34.	Kenya	1992	21,000	
35.	Kuwait	1994	600	12.5% irrigated area
36.	Kyrgyzstan	1990	1,41,000	13% irrigated area
37.	Lebanon	1993	21,000	24% irrigated area
38.	Libya	1990	4,70,000	100% irrigated area
39	Malawi	1992	11,300	
40.	Mali	1989	100	
41.	Malta	1990	150	
42.	Mauritius	1995	14,600	
43.	Morocco	1989	1,03,200	9.4% irrigated area
44.	Namibia	1992	1,845	
45.	Nicaragua	1980	16,460	26% irrigated area
46.	Norway	1980	69,500	Majority area with sprinklers undulating terrain cash crops
47.	Oman	1993	1,640	
48.	Saudi Arabia	1992	10,29,000	64% irrigated area
49.	Switzerland	1980		To protect crop against frost
50.	Syria	1993	30,000	
51.	Taiwan	1980		Orchards and garden
52.	Tchad	1988	3,200	

Sl. No.	Country	Year	Area Under Sprinkler Irrigation (ha)	Remarks
53.	Tunisia	1991	55,000	
54.	Turkey	1994	2,63,849	6.5% irrigated area
55.	Uganda	1980	121	
56.	United Arab Emirates	1993	3,748	
57.	USSR	1980	60,00,000	35% of irrigated area. Maldovia, Ukraine, Russian Federation.
58.	UK	1980	1,17,000	90% of total area
59.	USA	1991	85,72,621	35% irrigated area
60.	Yemen	1994	350	
61.	Yugoslavia	1980	49,192	35% irrigated area
62.	Zambia	1992	17,200	
63.	Zimbabwe	1980	1,10,000	70% irrigated area
	Total		2,15,73,567	

References : (i) Framji, K.K., Garg, B.C. and Luthra, S.D.L. (1983), "Irrigation & Drainage in the World", International Commission on Irrigation and Drainage, New Delhi

(ii) FAO, 1997, Irrigation in the Near East Region in Figures. Water Report No.9 FAO, Rome, 281 pp.

(iii) FAO, 1995, Irrigation in Africa in Figures. Water Report No.7, FAO/AGLW, Rome, 336 pp.

countries (Table 3.1). It is because an average Indian farmer is poor and cannot invest for the system. The plantation owners in the hills introduced sprinkler irrigation to irrigate tea, coffee and cardamom crops during dry season and dry spells of the monsoon period. In mid seventies, progressive farmers in Narmada valley in Madhya Pradesh, Southern part of Haryana and North East part of Rajasthan started using sprinkler system to overcome problems of water shortage particularly during summer. Adoption of this system gradually spread to larger area in the states of Haryana, Rajasthan, Madhya Pradesh, Maharashtra and Karnataka. However, in important agricultural states like Punjab, Uttar Pradesh and Bihar this system of irrigation is extremely limited.

Though detailed and accurate statistics are not available, it is estimated that the total area under sprinkler irrigation in India is about 0.66 m.ha out of the total irrigated area of 87.80 m.ha in 1995. Thus, this area is less than 1% of the irrigated area. The estimated number of sprinkler sets are about 1.35 lakhs in 1997. About 60% of area irrigated by sprinkler system is under field crops like cereals, pulses, oil seeds, cotton, sugarcane and vegetables, the rest being under tea, coffee, cardamom gardens in the western ghats and north eastern states.

The developmental work on sprinkler irrigation system has been mainly aimed at reducing the cost of the equipment and introducing smaller low pressure sprinklers. Till recently, the most popular piping material has been aluminum but to reduce the cost of the systems High Density Polyethylene (HDPE) pipes with suitable modification are introduced. The total area under sprinklers with HDPE/PVC pipes is less than 10% while the remaining area is under aluminum and steel pipe based sets. Indigenous manufacture of the system started some 25-30 years ago and there are about fifty firms in the country manufacturing the components of the system by 1996.

The spread and popularisation of the sprinkler irrigation method with farmers has received significant support from the various schemes involving subsidy of the Central and State Governments in the recent years. The details of these schemes are dealt in Chapter 9.

3.3 EVOLUTION OF SPRINKLER SYSTEM

The first ever sprinkler irrigation systems introduced on a large scale were the systems with hand moved laterals and impact type, rotating sprinklers. Later on, with the growing need to save labour and water, solid set, also called permanent system, carriage drive system with hose reel arrangement, giant sprinklers or gun sprinklers mounted on carriages were developed to facilitate rapid coverage of large areas, and in particular, those needing light supplemental irrigation. Mobile machines requiring minimum labour were developed in the sixties and seventies and at the same time, automation at various levels was introduced into sprinkler irrigation system. The soil moisture, pH of the soil water ,and nutrient status in the root zone of the plants can be monitored and the control system can be made to be responsive to the conditions in the root zone. Further, several fields can be irrigated by connecting the field units to a central master unit which is controlled by a computer.

3.4 ADVANTAGES OF SPRINKLER SYSTEM

A satisfactory irrigation system needs to provide the correct amount of water needed to maintain an adequate and constant soil moisture regime in the root zone of the crop. This shall be at a reasonable cost, with minimum use of water, land, power and labour. Sprinkler irrigation meets all these requirements. The relative advantage of sprinklers over surface methods will vary from place to place and time to time. Some of the advantages of sprinkler method include: (a) Water conservation, (b) Soil conservation and effective use of land, (c) healthy growth of crops with higher yields, and (d) Labour benefits.

3.4.1 Water Conservation

It is generally experienced that considerable savings will result in adopting sprinkler irrigation systems especially under conditions that are extremely adverse for the gravity methods. In gravity irrigation with unlined channels, conveyance losses are high while these are practically eliminated with use of sprinkler systems. Further, it is possible to apply water uniformly in all places with sprinkler irrigation. It is possible to apply water such that the water penetrates only the root zone with no wastage in the form of deep percolation (Fig.3.1). Therefore, it is possible to increase the area by one and a half to two times by changing from the gravity methods to sprinkler system with the same quantity of water. The sprinkler system of irrigation does not require any particular skill on the part of the irrigator and is well suited for supplemental irrigation. Further, by properly adjusting the duration of application, sprinkler irrigation can be used to apply for both small and large amounts of water efficiently. Higher levels of spatial uniformity and efficiency than gravity irrigation are achieved by sprinkler systems.

3.4.2 Soil Conservation and Use of Land

There are two situations of land conditions where sprinkler systems could be used advantageously : the land that is not irrigable by the gravity methods because of its highly undulating topography, high porosity of soil, steep gradients and shallow top soil, and the land which is irrigable but a part of the land is taken up by open ditches in gravity irrigation. By introducing this method, there will be no soil erosion problem, no compaction of soil during irrigation, no land leveling is required, and no land is lost for formation of water courses and field channels. Further, this method of irrigation will control leaching of salts. On the whole, the effect of properly applied sprinkler irrigation is more efficient for prevention of soil erosion and land degradation than gravity method of irrigation.

3.4.3 Benefits to Crops

By sprinkler irrigation method the soil moisture in the crop root zone is continuously maintained at optimum level and so healthy crop growth and higher yields are obtained. The quality of the produce is also good. The sprinkler method also helps in providing frost protection in winters, as well as cooling of crops in summers. Frequent and light irrigation is possible by this method. In this system, fertilisers and pesticides can be mixed with water and applied, and hence the efficiency of these inputs for crop production is more when compared to the gravity irrigation method.

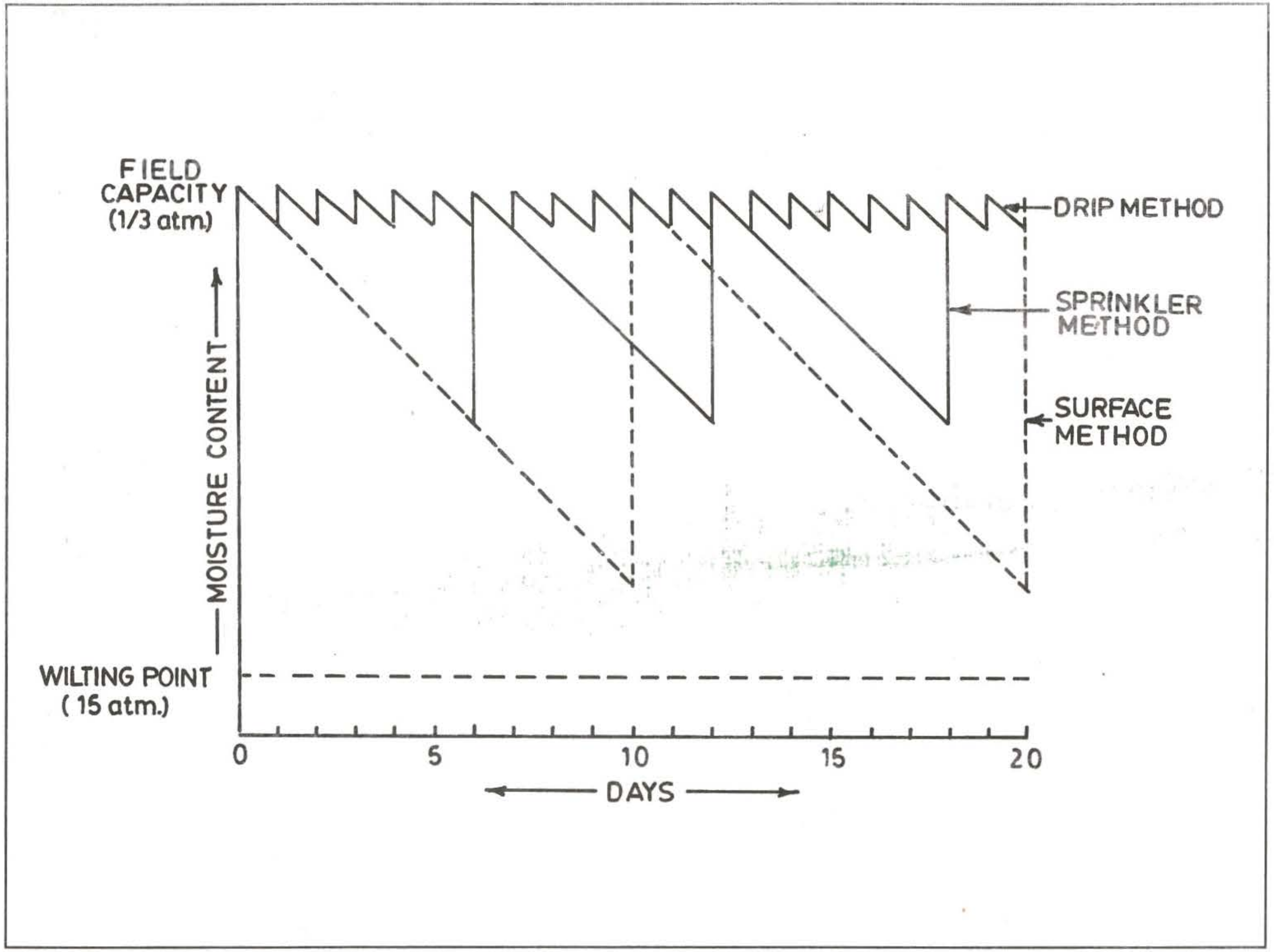


Fig. 3.1 Moisture availability for crops in different irrigation methods.

3.4.4 Benefits of Labour

Sprinkler irrigation is automated and since the lateral pipes need to be shifted only once in six to eight hours it generally leads to reduced labour requirements. Fertiliser and pesticides can also be applied through the sprinkler system thus affecting savings in labour costs. Sprinkler irrigation is also known to be associated with less infestation of pests and diseases thereby cutting down the plant protection costs.

Thus, the cumulative effect of these advantages is to ensure that a sprinkler system pays for itself in a few seasons when developing new areas, and it may well be economically attractive in the long run than the gravity method, since land leveling and construction of channels etc; are not needed.

3.5 SPECIAL USES OF SPRINKLER EQUIPMENT

The other important uses of the sprinkler systems are:

3.5.1 Seed Germination

The uniformity of crop stand and time of maturity is of economic importance for many crops, particularly for vegetables and flowers.The sprinkler system often ensures adequate seed germination with only one light application of water after seeding.

3.5.2 Application of Fertilisers

Dissolving soluble fertilisers in water and applying the solution through a sprinkler system is quick, economical, easy and effective. Once the apparatus for adding the fertiliser to the irrigation water is set up with minimum equipment, the crop being irrigated can be fertilised with less effort than is required for mechanical application. Penetration of fertiliser into the soil can be regulated by the duration of application in relation to the total irrigation period and the soil's hydro-physical characteristics. The fertiliser can be dissolved in water in a barrel or a closed container. There are several advantages in using sprinkler irrigation systems as a means of distributing fertilisers: i) application of both irrigation and fertilisation can be accomplished with only a marginally more labour than is required for irrigation alone. ii) close control can usually be maintained over the placement, as well as over lateral distribution. The uniformity of fertiliser distribution will be as good as the uniformity of water distribution.

3.5.3 Soil Amendments

Various soluble soil amendments, such as gypsum, sulphuric acid, limes, and soluble resins can also be applied through sprinkler systems. The method used is the same as those used to add soluble fertilisers.

3.5.4 Frost Protection.

Sprinkler irrigation systems can also be used for frost protection. The sprinkler system can be suitably modified by adding more lateral lines and sprinklers at predetermined spacing so that the entire field can be covered with a fine mist of water during freezing temperatures.

3.5.5 Application of Insecticides and Weed Control Chemicals

Insecticides, fungicides and weed control chemicals can also be injected through the sprinkler system in a way similar to the fertiliser application.

3.5.6 Cooling of crops

Many crop yields are seriously depressed by excessively high air temperature during the fruiting period. Temperatures above 35° C may cause blossom drop of beans and fruit drop of citrus, and temperatures in excess of 38° C for several days can cause losses of grapes up to 50 per cent. Sprinkling water by use of sprinkler system at low application rates will bring down ambient air temperature and leaf temperature by 5 °C or more. Crop losses can thus be minimised and fruit quality maintained. Cooling of crops by sprinkler requires a full coverage system, but unlike for frost protection, water can be applied intermittently (15 minutes off, 15 minutes on), thus conserving water. This method, however, requires water of reasonably good quality as saline water causes leaf burning.

3.5.7 Line Source Irrigation

In this method, a sprinkler lateral is used for irrigating several crops in the field. Since water distribution is more near the sprinkler riser; and reduces uniformly away from the line; the amount of water used in different zones and finally the yield of the crop can be assessed. This will be useful to decide the amount of water required to get maximum production per unit quantity and also fertiliser and water production functions.

3.5.8 Other Uses

There are numerous other uses for sprinkler irrigation equipment, both on the farm and elsewhere. The following are some of them:

i) Cooling livestock and poultry environments.

ii) Farm fire protection.

iii) Water distribution for compaction of earth fills.

iv) Settling of dust.

v) Log curing.

3.6 DISADVANTAGES OF SPRINKLER IRRIGATION SYSTEM

However, there are certain limitations which stand in the way of introducing sprinkler irrigation system on a large scale.

i) Wind effect: A carefully planned distribution pattern can be completely distorted by wind. Wind interference reduces effectiveness of uniform sprinkling. Wind conditions should be given due consideration in the original design of the system to minimise this disadvantage.

ii) Impact on fruits: Ripening soft fruit must be protected from the damage due to impact of the spray.

iii) System cost: The sprinkler method usually requires the highest initial investment as compared to surface methods, except where extensive land leveling is necessary for gravity irrigation.

iv) Energy needs: Energy requirements are usually high since sprinklers operate with a water pressure of 1.0 to more than 10 kg/cm^2 gauge pressure.

v) Adverse soil conditions: Fine textured soils that have a slow infiltration rate cannot be irrigated efficiently in hot windy areas. The sprinkler method is not suitable in soils with low infiltration rates. On some soils, movement of portable pipes after irrigation may pose a problem. This is true on soils that drain very slowly.

vi) Evaporation loss : More water is lost by evaporation during sprinkling than with surface flooding method of irrigation. The loss by evaporation will depend on climatic and operating conditions, and ranges from 2 to 5 per cent of the water used.

vii) Irrigation of orchards by sprinkling has unique problems. When sprinklers are used under a tree, low hanging branches may interfere with the uniform distribution of water. Where sprinklers are located above the trees, losses due to evaporation increase.

From the above discussion it is clear that better and easier water management is possible in the case of sprinkler irrigation. Research has proved that water saving in this method is about 30-40% compared to surface irrigation.

CHAPTER 4

SCOPE AND PROSPECTS OF SPRINKLER IRRIGATION

From the experience gained so far, it is well known that sprinkler method of irrigation is technically feasible and economically viable. This system is well recognised to achieve high water use efficiency, improved crop productivity and quality as well as savings in irrigation water and labour. Sprinkler irrigation system simulates natural rainfall process and is very well suited to all closely spaced crops in canal, tank and well irrigated areas. All close grown crops such as cereals, pulses, oil seeds, sugarcane, cotton and all plantation crops can be grown with sprinkler method of irrigation **(Annexure I)**. An advantage of this method of irrigation is that undulated lands and shallow soil areas can be irrigated without any land levelling. In coastal areas, ground water is available at shallow depths and sprinkler irrigation can be introduced depending upon the crop the quality and quantity of water. However, this system is not suited for using with brackish water.

Available irrigation facilities particularly groundwater supplies are depleting rather fast, while demand for water is escalating. The water crisis accentuates particularly during summer season over a sizable part of India. Complacency to this crisis could lead to immeasurable damage. There is an urgent need to resort to science based, economically viable, and technically feasible strategies. It is here sprinkler irrigation offers immense opportunities provided the much needed political will, policy support and organisational endeavour are available. Present environment policy is highly favourable to introduction of the sprinkler method of irrigation on a large scale. The scope and potential for large scale coverage by sprinkler irrigation method are projected to be vast in the context of nearly a decade of experience in India itself.

Further, as mentioned in chapter 1, in the context of opening of the country's economy to international markets, a major shift of investments from industry to agriculture is anticipated with emphasis on commercial crops. Accordingly, the cropped area under commercial crops is going to increase substantially in the coming years. The economic and effective use of the limited water resources using the sprinkler system of irrigation, particularly for the commercial crop sector, therefore, becomes important.

The farmers in Haryana, Rajasthan, Madhya Pradesh and Gujarat have introduced the sprinkler method of irrigation in large scale and enlarged their income base and living standards. Similar development should take place in other parts of the country in the coming years.

4.1 SCOPE OF SPRINKLER IRRIGATION

A wide array of closely grown field crops such as millets, pulses, gram, wheat, sugarcane, groundnut, cotton, vegetables and fruits, flowers, spices and condiments could be brought under the purview of sprinkler irrigation; particularly during *rabi* and summer seasons. The potential for adoption of sprinkler irrigation is very vast because the area under the above mentioned crops occupy a substantial portion of the gross cropped area as given in Table 4.1. Current area under the sprinkler system is just about 1.5% of the area under these crops. It should be possible to enlarge the coverage under a phased programme particularly in canal irrigation command areas. Care should however be taken that the techno-economic feasibility in each individual case is established including the scope and sources of funding before actually going in for the introduction of the sprinkler irrigation.

Table 4.1
Potential area for sprinkler irrigation in India

S.No.	Crop	Area (m.ha)
1.	Cereals & Millets (excluding rice)	27.6
2.	Pulses	4.2
3.	Oil seeds	11.1
4.	Cotton	2.6
5.	Condiments & Spices	1.2*
6.	Fruits & Vegetables	2.5*
7.	Sugarcane	3.3
	Total	42.5

* upto 91-92. For the other crops, cropped Area is upto 94-95 and coverage under Irrigation is upto 92-93.
Source: Directorate of Economics & Statistics, Ministry of Agriculture, G.O.I., 1996

4.1.1 Export Oriented Crops

Export oriented crops, such as vegetables, flowers and horticultural crops and plantations are found to perform quantitatively and qualitatively better under sprinkler system. Sprinkler irrigation systems are in operation for long time in plantation crop areas. Plantation crops such as tea, coffee, cardamom are grown in about 0.12 m. ha. in India. The international market demand for the products of these crops is vastly expanding and should be exploited fully by appropriate policy instruments.

4.1.2 Command Areas of Irrigation Projects

Gravity flow system of irrigation is the common method of irrigation in all the command areas of irrigation projects in India. Where supplies are planned for dry crops like groundnut, millets, vegetables and pulses, it would be economically rewarding if sprinkler irrigation can be introduced in these areas. The area available under this category is estimated to be about 10 m.ha. This is based on the assumption that at least 50% of the 20 m.ha under the CAD Schemes will be under irrigated-dry (ID) crops, which can be brought under sprinkler irrigation. The installation of sprinklers in the canal command areas in Haryana during seventies is first of its kind in the country. Operation of these sprinklers depends on the rotational programme of the canal and dependability of electricity supply to run the pumps. Design of the system is guided by these considerations.

In Haryana, installation of sprinklers by the farmers themselves started in the year 1973-74. This followed by installation of the sprinkler systems by the State Government during 1978. The Bhiwani district of Haryana has a high concentration of sprinklers installed by farmers. This system is now adopted in other parts of Haryana, parts of Rajasthan, Madhya Pradesh, Punjab etc.

There is a strong case for use of sprinklers in the commands of gravity water storage projects especially in the head reaches of commands which suffer from the problems of wasteful utilisation leading to water logging and salinity build up. A giant liner (Jumbo) sprinkler system with automated motion can command an area about 50 ha. Farmers can jointly own such system under a society with legal constitution. Information on selecting appropriate sprinkler system configuration and operational procedures to match the crops and climate need to be developed through field based research. Shortage of the available water resources coupled with increasingly competing demands for water for agriculture, industry and drinking and municipal purpose, make farmers look for the advanced methods of irrigation. The awareness of the farmers to increase the production and income have encouraged them to utilise the water more efficiently by switching over to sprinkler irrigation systems. Inspite of the advantages, the area under sprinkler irrigation has not increased to an extent comparable to the increase in the total irrigated area in India.

The financial requirements in bringing large areas under this water saving method of irrigation is not much as compared to the benefits accruing by way of increase in area that can be brought under irrigation, improved quality of the production and productivity expected from these lands specially for commercial crops. In addition, it will generate employment opportunity to a large segment of rural and semi urban population. While selecting the areas in different states, the rainfall pattern groundwater depletion, quantity and quality of water should also be taken into consideration.

Further, sprinkler irrigation method can be advantageously adopted in situations such as waste land areas, hills and semi-arid regions, and water scarce areas. The system can also be used with community wells and on custom-hire basis. Thus, vast scope exists for large scale adaption of sprinkler irrigation method. This would also substantially contribute to higher levels of agricultural production on sustainable basis.

Sprinkler System in-Operating in Gram Fields in Rajasthan.

CHAPTER 5

ADOPTION OF SPRINKLER IRRIGATION IN INDIA

Sprinkler irrigation system is used as a method of modern irrigation by progressive farmers all over the world. Intensive efforts by the pioneers in this field created awareness about the sprinkler irrigation system. Initially, only the simple designs were introduced so that the system could be operated even by those who are not fully conversant with it. Gradually more efficient and complex systems have come into vogue.

The general feeling is that the sprinklers should be used only when other systems of irrigation cannot be introduced for various factors like hilly terrain, unfavourable soil conditions or an extreme shortage of water. Thus, the introduction of sprinkler irrigation was mainly on account of inevitable factors and not driven by a desire to adopt efficient techniques of irrigation.

In India, sprinkler irrigation was introduced mainly in hilly regions such as Western ghats in Kerala, Tamil Nadu, Karnataka and in the north eastern states especially for the plantation crops like tea, coffee, cardamom etc. This is necessitated due to water deficiency in the months of January to May and thereby the need for economic use of available water. Further, for coffee, irrigation is required at the time of flowering, which occurs during the months of no rainfall in that region.

There are many areas like parts of Rajasthan, Haryana, Karnataka, Tamil Nadu, etc. where water scarcity prevails. In some areas, the soils are so porous that gravity irrigation is ineffective. Sprinkler irrigation is appropriate for such areas. In order to encourage conservation and economy of use of water, Central and State Governments have been providing incentives like loans and subsidies to the farmers who wish to introduce sprinkler system. These incentives induced large number of farmers to go in for the adoption of sprinkler irrigation for different crops. Currently (1997) about 6.6 lakh ha is under sprinkler irrigation in India.

5.1 DEVELOPMENT IN MADHYA PRADESH

Though Madhya Pradesh comes under medium rainfall region, due to factors like black soils, unpredictability of rainfall and long dry spells in the monsoon etc. sprinkler system of irrigation is particularly suitable to grow soyabean in most parts of the state. By 1997, Madhya Pradesh with an area of about 1.50 lakh ha. under sprinkler irrigation, is the leading state in area coverage.

An example of use of sprinkler is at the state owned Babai farm in Hoshangabad district. The total area of the farm is 1600 ha and consists mainly of sandy soil.

There was no source of gravity water and the annual rainfall amount and its time distribution do not suit cultivation of any crop. A total number of 80 tube wells were sunk in the farmland at intervals of 300 to 400 m. Gravity irrigation was not suitable due to heavy conveyance loss (more than 50%) and hence sprinkler irrigation was adopted. Portable sprinkler sets were used. On an average, the overall yield of hybrid wheat was 10.4 q/ha. A saving in the cost of fertilizer application was effected upto 25%. Seepage loss of 55% in the gravity method was eliminated while evaporation losses were only of the order of 5 to 6% with the use of sprinkler irrigation. Thus the farm has proved to be an excellent demonstration of use of sprinkler irrigation method.

Madhya Pradesh is implementing command area development programme for many years. The water utilisation efficiency of the conventional gravity irrigation methods was not upto the expectation though lot of money was spent for the development of the same. Hence the government is seriously considering to introduce sprinkler irrigation system in these areas also.

5.2 DEVELOPMENT IN HARYANA

Sprinkler irrigation is very popular in Haryana State. The government departments/ farmers are taking keen interest in popularising the method. The area under sprinkler is about 83,600 ha.by 1997.

Sprinkler irrigation is adopted in Haryana for all most all crops (except rice and jute) and the most soils and variable topographic conditions. The conditions of soil, topography, irrigation source and climate prevailing in south western part of Haryana, particularly in the districts of Bhiwani, Mahindergarh and parts of Rothak, Sirsa and Hisar are most appropriate for sprinkler irrigation.

Large number of farmers of these areas have adopted sprinkler irrigation and during the period 1975-1995, number of sprinkler sets owned by farmers have increased from 85 to more than 15000. About 18% of the area is reported to be sandy soil and the sprinkler system is ideal for these areas. The Haryana irrigation department installed more than 200 community sprinkler sets (each irrigating about 40 ha.) on canal systems (Jui canal, Jui feeder and Sewani canal commands).

5.3 DEVELOPMENT IN RAJASTHAN.

Sprinkler irrigation system was introduced in the state in the early eighties. Initially aluminium pipe based sprinkler systems were adapted by the farmers. Sikar, Jhunjunu, Nagaur were the districts where adaption of sprinkler system was maximum. During the year 1985 HDPE pipe based sprinkler system was introduced. Adaption of sprinkler system accelerated in the late eighties and early nineties. The other areas where the system was adopted are Udaipur, Sirohi, Jalore, Banswara, Jodhpur and

Bikaner. Sprinkler system was also introduced in canal irrigated areas of Bikaner and Kota. The sprinkler irrigation system is mainly used in the wheat, gram, mustard and vegetable crops. By 1997, the total area under sprinkler in Rajasthan is about 48000 ha.

5.4 DEVELOPMENT IN OTHER STATES

Sprinkler irrigation is also adopted on large scale in the following States:

a) Andhra Pradesh
b) Gujarat
c) Maharashtra
d) Karnataka
e) Kerala
f) Orissa
g) Tamil Nadu, and
h) Uttar Pradesh

Adoption of sprinkler irrigation system has also started in Punjab (arid and semi arid areas), eastern Uttar Pradesh and part of Orissa. In Punjab farmers are coming forward to install sprinkler system in shallow tube well command areas.

The use of sprinkler method of irrigation depends on

a) degree of scarcity of Water,
b) Topography,
c) The need of spray for the crop,and
d) Increase in productivity.

The extent of area irrigated by sprinkler irrigation in various states are given in Table 5.1 (See also Fig.5.1).

During the eighth five year plan period, the adoption of sprinkler sets has increased substantially due to various subsidy schemes introduced by the Govt. of India (Table 5.2). Details of adoption of sprinkler irrigation for various crops under the Centrally sponsored schemes are given in **Annexures II to V.**

Table 5.1
Statewise Area under Sprinkler Irrigation

States	Area under sprinkler irrigation, in hectares
Assam	90000*
Andhra Pradesh	17090
Bihar	160
Gujarat	27740
Haryana	83600
Himachal Pradesh	70
Jammu & Kashmir	30
Karnataka	41900
Kerala	5800
Madhya Pradesh	149980
Maharashtra	33120
Orissa	400
Punjab	200
Rajasthan	47850
Tamil Nadu	32130
Uttar Pradesh	7360
West Bengal	120040*
Other States+UTs	500
Total	658500

* Mainly for plantation crops

Table 5.2
Status of sprinkler irrigation development during VIII plan period (1992-97)

State	Number of sprinkler sets installed*					
	92-93	93-94	94-95	95-96	96-97	Total
Andhra Pradesh	809	1159	3791	7652	5740	19151
Gujarat	1020	1597	2658	5514	2105	12894
Haryana	652	NA	712	1964	760	4088
Karnataka	1524	1202	927	1541	1310	6504
Madhya Pradesh	146	307	1068	8576	6530	16627
Maharashtra	2131	2577	2996	6081	4755	18540
Rajasthan	907	2269	6360	13187	7030	29753
Tamil Nadu	1988	2221	3477	3125	1264	12075
Uttar Pradesh	343	809	3583	3278	3600	11613
Other States	61	143	43	1344	1659	3250
Total	9581	12284	25615	52262	34753	134495

* Average area commanded per unit equals 0.6 ha.

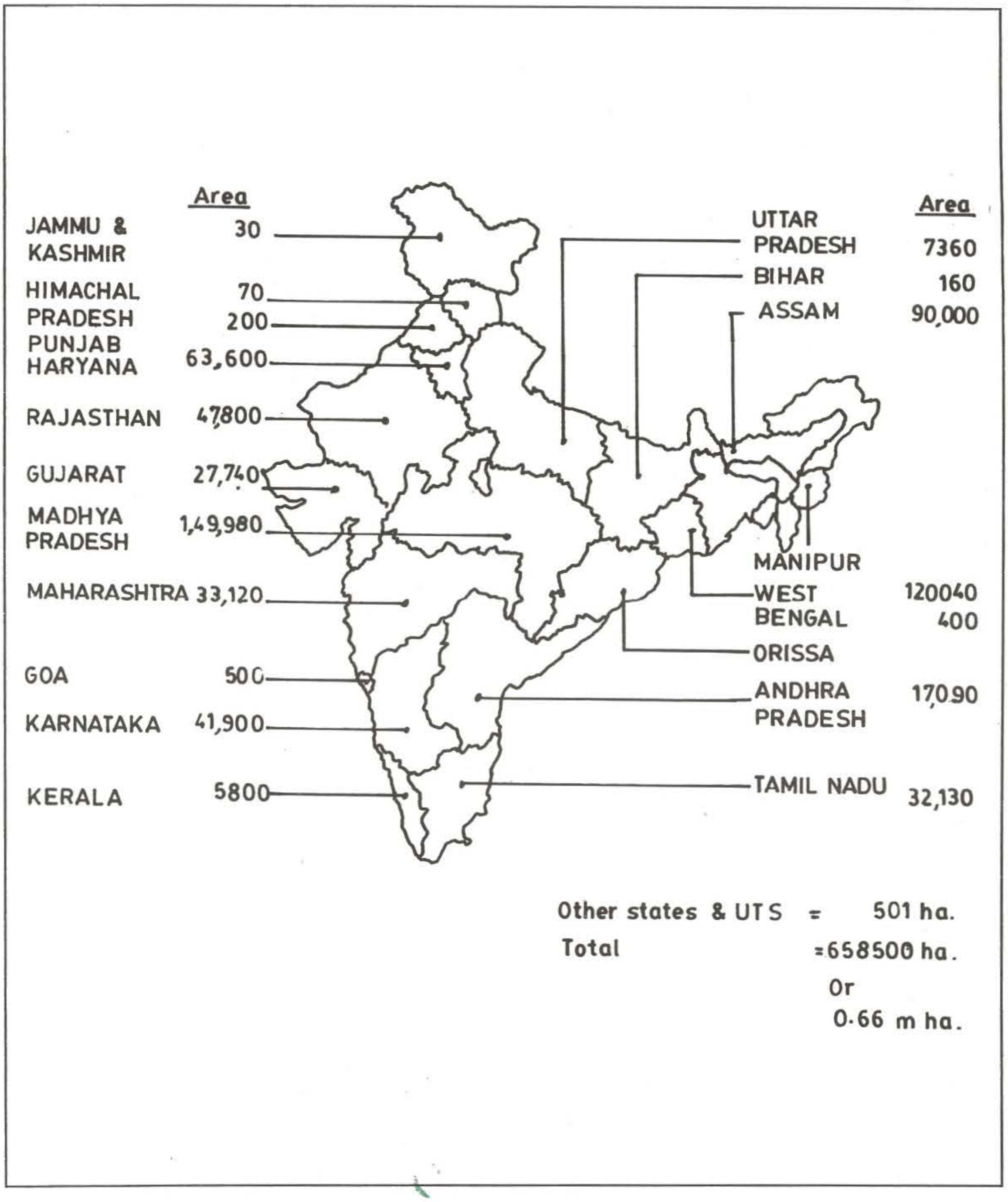


Fig. 5.1 Area under sprinkler irrigation (hectares).

5.5 SPRINKLER IRRIGAITON IN CANAL COMMAND AREAS

For economic and efficient use of water, it is necessary to use the practice of sprinkler irrigation. This can be used not only in groundwater application but also in canal water application. The experience in the Haryana State is given here.

The irrigation department of Haryana State launched the installation of sprinklers in 1978 on the existing canal net work. The installation of sprinkler system in the canal network by the State Government is first of its kind in the country. Between 1978 and 1981, 131 sprinkler sets were installed in the Lift Command, Bhakra Command and Western Jamuna Canal (WJC) areas. These sprinkler sets were installed and operated by the Irrigation Department. The area selected for experimental sprinkler irrigation was chronically deficit in water. These sets were installed in lift canal command areas for irrigation of lands of undulating terrain where extension of irrigation by normal method of construction of water courses was not feasible. In the canal command areas of established Western Jamuna Canal and Bhakra Canal System, these sets were installed to extend irrigation to high lands which were identified as non-command areas within the gross area of the canal command. Typically the command areas of the distributary and minors in which these sprinklers are installed are divided into groups and the regulation of irrigation supply is made in 8 days rotation. The periodicity of the rotation is dependent upon the available supplies for pre determined rotational programme and aims to ensure equitable distribution of water. Generally, the system runs for 16 days out of 24 days in *kharif* and 8 days out of 24 days in *rabi*. Some times it is 16 days out of 24 days when good supplies are available in *rabi*.

The drawal of water from the canal for sprinkler sets is done by installing pumping sets along side of the bank of canal (Fig.5.2). The delivery of the pumping set is connected directly to the sprinkler main pipes.

The successful performance of the sprinkler sets on canals is facilitated by ensuring adequate depth of water in the canal, provision for silt trap, and monitoring of the running hours of the pump so that the water is made available to the crop as per schedule.

This, in turn, requires proper maintenance of the canals, pumping sets and ofcourse the sprinkler set itself. With the rising maintenance costs, further installation of sprinklers in the public sector has been guided by incentives from the government and willingness to takeover the major operation and maintenance by the farmers themselves, etc. .

Where the farmers come forward for forming associations and taking over of the operation and maintenance, the government is considering to make further provisions of even constructing storage tanks for sustained and regular running of the sprinklers to meet the irrigation needs at critical junctures for crop maturity.

Fig. 5.2 Water being pumped for Sprinkler Irrigation System in Jui Canal Command area - Haryana.
(Courtesy : Irrigation Departmet Govt. of Haryana)

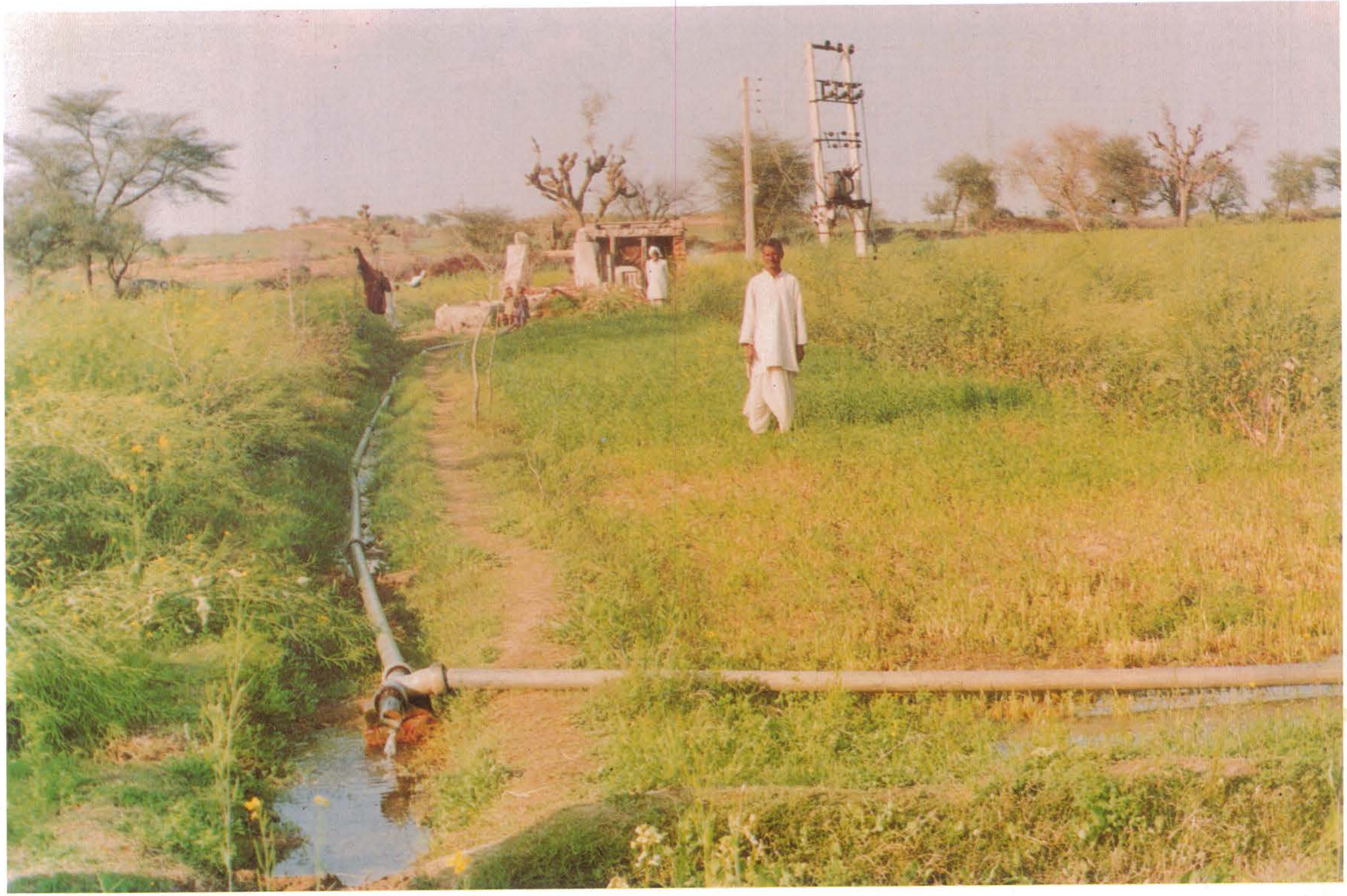


Fig. 5.3 A view of the layout of the piping system for Sprinkler Irrigation - Jui Canal Command area, Haryana

CHAPTER 6

RESEARCH ON SPRINKLER IRRIGATION

The research work on the use of sprinkler irrigation is mainly confined to the area of design of layout, operational uniformity, saving in water and the water use efficiency for different crops. In India, the adoption of sprinkler systems is limited to portable type system, being operated in medium pressure range. The related research work/studies have been taken up by various agricultural universities, ICAR research institutes, manufacturers, on experimental farms, and on farmers fields. A list of these institutions is provided in **Annexure VI**.

A number of research schemes have been sponsored by the Ministry of Water Resources **(Annexure VII)** and the Ministry of Agriculture at different institutions as adhoc research schemes. As mentioned earlier, the adoption of sprinkler systems in India started with tea and coffee plantations in mid fifties and later on extended to various other crops in mid seventies. Some of these plantation companies have their own research units. Their experiences also contributed to research knowledge base.

A brief account on research results is given in the following paragraphs :

6.1 DESIGN ASPECTS OF SPRINKLER SYSTEM LAYOUT

The design of sprinkler system is judged as "good" or "bad" based on the Water distribution pattern as obtained from the sprinkler system. The performance of the sprinkler system fluctuates due to wind effect, operating pressure, nozzle size and layout of sprinkler in the field. The important findings of the research efforts are summarized and given below :

6.1.1 Wind Effect :

The wind effect on the water trajectory from a single sprinkler nozzle is very high. Normal range of wind velocity is 2 Kmph to 15 Kmph. Increase in the wind velocity or spacing of sprinkler nozzles results in decrease of the uniformity coefficient, C_u, which is a measurable index of the degree of uniformity obtainable for any size sprinkler operating under given conditions. A view of the field experimental set up for determination of uniformity coefficients using catch cans spread over the area is shown in Figure 6.3.

With the increase in the wind velocity, the trajectory is not only stretched parallel to wind but also squeezed perpendicular to wind direction. Under high wind velocity conditions it is beneficial to keep larger length parallel and shorter side perpendicular to wind direction in a 6 x 12m spacing of sprinklers. Further, for higher wind velocities (>25 kmph) the grid size shall be the smallest possible. Under normal wind conditions, a 6m x 6m grid is recommended. The uniformity coefficient of a sprinkler system was reported to decrease from 83.35% to 65.02% with the increase in the wind velocity from 2.3 to 14 km/hr. (Jaspal Singh et.al,1990.). At the same time, the depth of application at the central region was reported to increase with increase in wind velocity. It was observed that lesser the spacing of sprinklers, the better the uniformity coefficient for all cases.

The studies on wind effect also showed that at a pressure of 3 kg/cm^2 with the spacing of (18m x 12m) gave higher water distribution efficiency under wind velocity ranging from 3.38 kmph to 15.45 kmph (Agarwal, M.C., 1995). The distribution pattern resulting from different spacing combinations of laterals and sprinkler nozzles are shown in Fig. 6.1. The distribution efficiency was reported to be appreciably affected by wind velocity and it ranged from 69.5 to 86.2 percent.

6.1.2 Pressure Effect

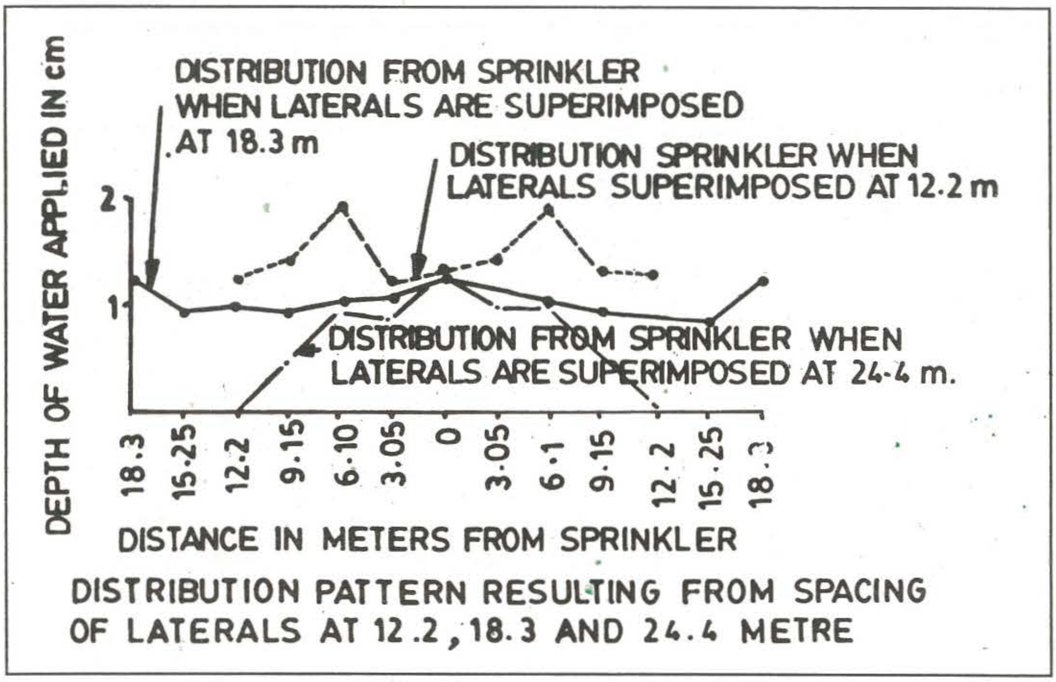
The effect of pressure on water trajectory is more pronounced than that of nozzle size. High pressure and larger nozzles gave high depth of application, as compared to lower pressure and smaller nozzle sizes throughout the length of the trajectory. A high pressure of 4.2 kg/cm^2 gave better distribution under calm or low wind conditions but the distortion was more with high wind velocities. On the other hand, a low pressure of 2.1 kg/cm^2 was reported to give better uniformity than a pressure 4.2 kg/cm^2 at high wind velocities upto 8-16 km/h (Jaspal Singh et.al,,1990). (Figs. 6.2 & 6.3).

It was generally reported that larger nozzles, when operated at a higher pressure gave better distribution for all feasible spacings. The depth of water estimated by assuming a triangular pattern of distribution from a single sprinkler does not give comparable results. The theoretically calculated depth was observed to be quite low than the actual value.

6.2 IRRIGATION WITH SALINE WATER

The field experiments with three levels of irrigation water quality, (water of poor quality of 0.25, 6 and 12 dsm^{-1}) under sprinkler and the traditional gravity methods of irrigation were conducted to compare the performance of *kharif* and *rabi* crops (Agarwal,1995). The pre-sowing irrigation was applied with normal water and flood irrigation method. The results obtained for different crops are as under :

Bajra : The results showed that application of highly saline water of 12 dsm^{-1} by sprinkler method to Bajra crop during hot days was more detrimental in comparison to flooding method particularly during early growth stage of the crop (Table 6.1). It was recommended that even while using moderately low saline water (6 dsm^{-1}) to these crops by sprinkler, it should be done only during the night or on a cloudy day when temperature is low and humidity is higher. The highly saline water when



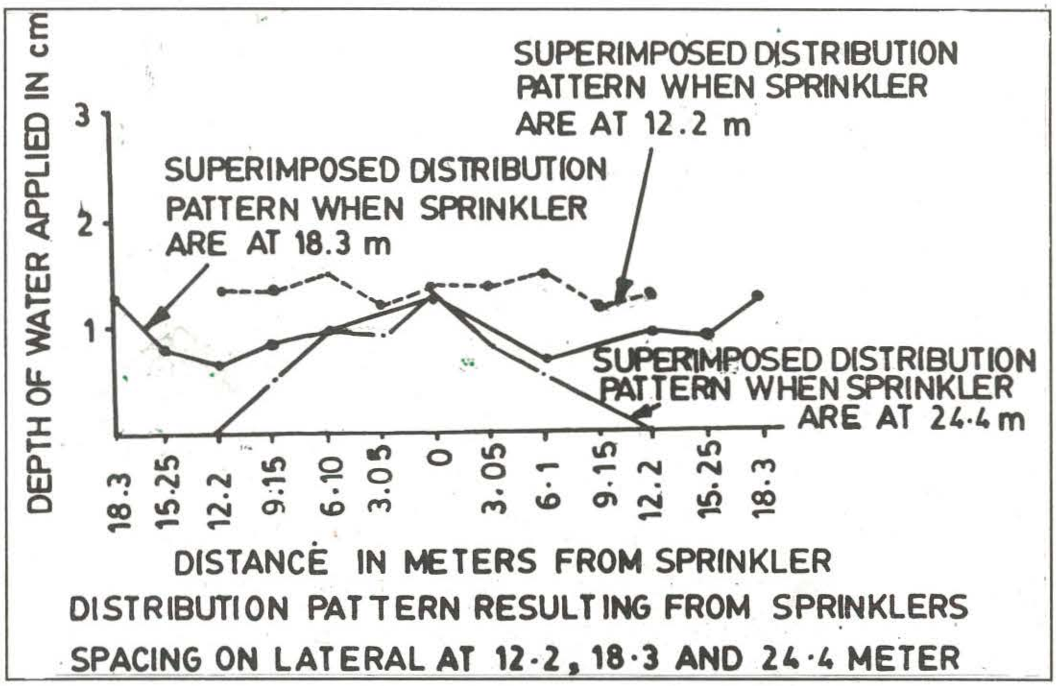


Fig. 6.1 Water distribution pattern for different spacings of sprinklers and laterals.

Fig. 6.2 A view of pressure gauge in operation in the farmer's field.
(Courtesy : WTC, IARI, New Delhi)

Fig. 6.3 Placement of catch cans for determination of uniformity coeffieient.
(Courtesy : P.D.C. Pantnagar)

applied through sprinkler resulted in severe leaf burning of Bajra and the sodium content in the leaves was found to be much higher (13 times) as compared to gravity irrigation. The reduction in the yield of Bajra under both the irrigation methods was appreciable when the salinity of irrigation water increased from 6.0 to 12.0 dsm^{-1}.

Table 6.1

Yield of Bajra (q/ha) under different water qualities (dsm^{-1}) and irrigation methods.

Year	Sprinkler			Gravity		
	Normal Water	6 dsm^{-1}	12 dsm^{-1}	Normal Water	6 dsm^{-1}	12 dsm^{-1}
1976	33.62	-	14.64	28.82	-	22.15
1977	14.50	16.00	10.00	16.62	15.33	11.45
1978	28.13	27.15	20.06	26.44	22.92	17.58
Mean	25.40	21.63	14.90	23.80	19.10	17.06
Na^+ in Leaves (mg/g)	0.8	-	40.8	0.8	-	2.8
C.D. at 5%		1976		1977		1978
Irrigation Method		NS		NS		2.66
Water Quality		7.1		1.29		1.03

N.S. :Not Significant

Source: Agarwal, M.C., 1995, Haryana Agri.University, Hisar

Cotton : The application of saline water by sprinkler system led to a greater yield reduction as compared to traditional gravity method because the first irrigation to cotton in the month of June i.e., 45 days after sowing is essential as temperatures even during night time are higher. (Table 6.2).

Table 6.2
Yield of Cotton (q/ha) under different water qualities (dsm^{-1}) and irrigation methods.

Year	Sprinkler			Gravity		
	Normal Water	7 dsm^{-1}	12 dsm^{-1}	Normal Water	7 dsm^{-1}	12 dsm^{-1}
1980	22.65	19.06	15.93	23.81	18.92	18.38
1981	22.34	16.71	12.89	22.28	18.47	17.00
1982	23.40	14.27	13.69	22.87	17.17	16.01
Mean	22.79	16.23	13.36	22.98	18.18	17.13

C.D at 5%			
Year	1980	1981	1982
Irrigation Method	0.72	0.39	1.01
Water Quality	0.86	0.48	1.24
M x Q	1.21	0.68	1.45

Source: Agarwal, M.C., Haryana Agril.University, Hissar, 1995

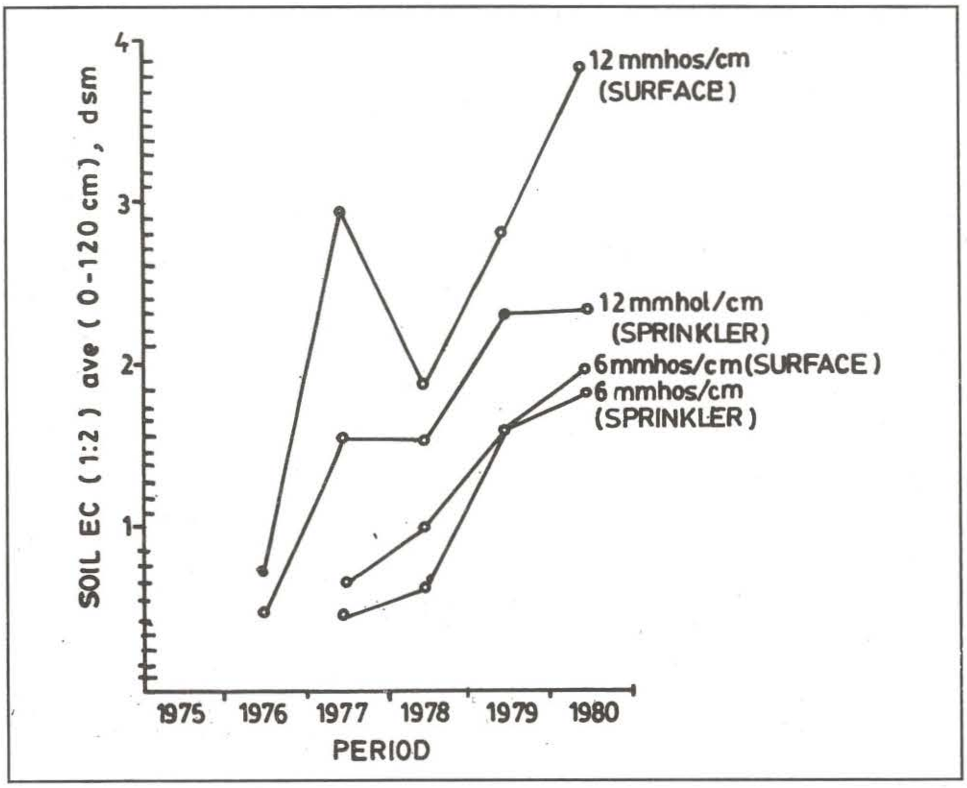


Fig. 6.4 Soil salinity in relation to irrigation water quality and method of irrigation

Wheat : Application of saline irrigation water to wheat crop through sprinkler system did not cause any higher adverse effect over its application by the traditional gravity method (Table 6.3). The reduction in the wheat yield was less as compared to Bajra and cotton with an increase in the salinity of water under both the methods of irrigation . The water use efficiency was higher under sprinkler irrigation and it decreased to a greater extent with increase in salinity of irrigation water and also under traditional gravity method (Table 6.3).

Table 6.3

Yield of Wheat (q/ha) under different water qualities (dsm^{-1}) and irrigation methods.

Year	Sprinkler			Gravity		
	Normal Water	6 EC dsm^{-1}	12 Ec dsm^{-1}	Normal Water	6 EC dsm^{-1}	12 EC dsm^{-1}
1976	37.70	-	38.00	40.00	-	44.80
1977	42.70	-	40.40	43.60	-	42.20
1978	33.90	33.80	28.00	38.00	32.50	27.90
1979	33.40	40.40	35.40	40.00	35.70	36.20
Mean	25.40	21.63	14.90	23.80	19.10	17.06
Ave. wue kq/ha-cm	1.07	1.07	0.97	0.97	0.88	0.83

Source: Agarwal, M.C., Haryana Agril.University, Hisar 1995

Barley : For barley crop yield obtained by application of highly saline water by sprinkler is superior to gravity method of irrigation (Table 6.4). The water use efficiency under sprinkler method and with all the water qualities is higher than in traditional gravity method. The water use efficiency, as in the case of wheat under gravity method was more adversely affected with increasing salinity of irrigation water. This was due to the fact that application of saline water through sprinkler caused lesser salt accumulation in the soil as shown in Fig. 6.2. Under sprinkler irrigation the leaching efficiency per unit of water applied is reported to be higher than under flood irrigation because due to controlled rate of application water moves through the micro-channel (pores) whereas under flood irrigation much of water moves through cracks and macro pores than through micro pores.

Table 6.4

Yield of Barley (q/ha) under different water qualities method of irrigation.

Year	Sprinkler			Gravity		
	Canal water	EC dsm^{-1}		Canal water	EC dsm^{-1}	
		7	12		7	12
1980	27.60	23.90	18.80	32.40	25.50	16.80
1981	32.00	27.20	27.70	31.30	24.60	21.60
1982	44.90	36.30	31.10	41.70	33.90	31.40
Mean	34.80	29.10	25.90	35.10	28.00	23.30
Ave. wue kq/ha-cm	1.59	1.33	1.17	1.47	1.17	0.98

	C.D at 5%		
Year	1980	1981	1982
Irrigation Method	2.83	1.47	6.93
Water Quality(Q)	N.S.	N.S.	N.S.
M x Q			

Source: Agarwal, M.C., Haryana Agril.University, Hissar, 1995

6.3 CROP WATER USE AND YIELD

It is a common experience that use of sprinkler irrigation system leads to savings in irrigation water as compared to the conventional gravity irrigation methods (Table 6.5).

It is also observed that the water use efficiency is higher with sprinkler irrigation system. Considerable research efforts have gone into in establishing these facts in numerous research organizations in India. A brief account of these research results is given below :

Table 6.5

Relative Performance of Crops with Sprinkler Irrigation in Comparison with that of Traditional Irrigation Methods

Sl. No.	Crops	Location	Yield (q/ha)		Irrigation Water (cm)		Water use Efficiency (q/ha-cm)		Advantage of Sprinkler	
			Sur. Irrgn.	Spr. Irrgn.	Sur. Irrgn.	Spr. Irrgn	Sur. Irrgn.	Spr. Irrgn.	Saving of Water (%)	Increase Yield (%)
1.	Wheat	Rahuri	32.41	36.39	35.0	20.25	0.93	1.79	42.14	12.28
		Udaipur	26.61	33.02	33.02	14.52	0.81	2.27	56.03	24.09
		Hissar	44.80	48.70	33.94	32.68	1.32	1.49	3.89	8.70
2	Bajra	Rahuri	6.97	8.33	17.78	7.82	0.39	1.07	56.02	19.51
3.	Jowar	Rahuri	4.92	6.62	25.40	11.27	0.19	0.59	55.63	34.55
4	G.Nut	Rahuri	23.24	28.98	90.00	62.00	0.26	0.47	31.11	24.69
	(Summer)	Junagarh	13.00	16.00	91.00	65.00	0.14	0.25	28.57	23.08
		Dharwad	33.96	39.86	76.30	63.60	0.45	0.63	16.64	17.37
		Punjab	5.50	11.90	68.60	50.20	0.08	0.24	26.82	116.38
		Navsari	31.00	30.00	56.00	44.00	0.55	0.68	21.43	-3.22
	(*kharif*)	Rahuri	18.31	22.15	21.00	14.00	0.87	1.58	33.33	20.97
5.	Cotton	Navsari	6.99	7.04	40.64	29.65	0.17	0.24	27.04	0.71
		Punjab	10.00	15.00	91.10	58.60	0.12	0.26	35.68	50.00
6.	Barley	Bikaner	24.09	28.15	17.78	7.82	1.35	3.59	56.01	16.85
		Hissar	35.10	34.80	23.87	21.88	1.47	1.59	8.34	-0.85
7.	Gram	Hissar	6.55	9.91	17.78	7.82	0.37	1.27	56.02	51.29
8.	Oil Seeds	NCPA	8.33	9.34	60.00	30.00	0.14	0.31	50	12.12
9.	Garlic	Rahuri	69.99	73.99	84.00	60.00	0.83	1.23	28.57	5.71
10.	Chilies	Pune	17.41	21.52	36.00	24.00	0.48	0.89	33.33	23.61
	(*kharif*)	Rahuri	17.15	20.91	39.00	26.00	0.44	0.80	33.33	21.92
11.	Sunflower (Rabi)	Rahuri	16.02	19.19	30.00	20.00	0.534	0.96	33.33	19.79
12.	Sugarcane	Rahuri	792.10	866.30	245.00	188.00	3.23	4.61	23.26	9.37
		Dharwad	55.70	48.00	51.40	43.50	1.08	1.10	15.36	-13.82
13.	Sorghum (*kharif*)	Rahuri	44.12	54.97	18.00	12.00	2.45	4.58	33.33	24.59
14.	Onion (Summer)	Rahuri	334.90	412.70	78.00	52.00	4.29	7.94	33.33	23.23
15.	Maize (*kharif*)	Udaipur	15.62	18.10	12.80	9.00	1.22	2.01	29.69	15.88

Sources : Gujarat Agril.University, Rajasthan Agril.University, Mahatma Phule Krishi Vidyapeeth,Rahuri, Harayana Agril.University Hisar, University of Agril.Sciences, Dharward, Punjab Agril University, Ludhiyana N.C.P.A., New Delhi.

6.3.1 Saving in Irrigation Water

Adoption of sprinkler irrigation system has shown a positive result towards the saving in irrigation water. The saving in irrigation water is mainly due to the fact that a properly designed sprinkler system, when operated at recommended pressure gives better water application efficiency as compared to traditional gravity irrigation methods. Further, the system enables a user to apply the desired depth of irrigation water. The research carried out using sprinkler irrigation systems, under various agro climatic conditions in India for different crops, indicates that the saving in irrigation water ranges from 10 to 55 percent. The variation in saving of water is mainly due to variations in soil, climate and crops. For instance, saving of irrigation water in the case of wheat crop ranged between 42-56%, for groundnut crop the range is between 11-33%. For low water requiring crops like Bajra and Jowar the saving of irrigation water is as high as 55%. The detailed results for various crops are given in Table 6.5. The water use efficiency in most cases improved by 100-200% as compared to conventional gravity irrigation methods.

6.3.2 Enhancement of Productivity

The research data on yield of a crop irrigated with conventional gravity irrigation method and sprinkler irrigation method were compared and it was observed that sprinkler irrigation method helps in enhancing the productivity of the crop. For instance in wheat crop it was observed that on an average the productivity of crop increases by 15%, while in respect of groundnut and oilseeds crops, it is 21% and under low water requiring crop like Bajra, Jowar, barley and gram, it is around 25%. Plantation crops were the first where sprinkler irrigation was introduced in India. This was primarily motivated by various factors including undulating terrain, high porosity of soils, need for controlled application of irrigation water. No research data of research efforts aimed at evaluating the relative performance of sprinkler irrigation in plantation crops is available.

However, information on yield of tea plantations grown in plains with conventional irrigation method and those grown in hilly terrain with sprinkler irrigation method indicates the yields are higher in the later case. Besides the experiences gained at research forms, it is necessary to study the experiences on the farmer's field; in the form of out reach research studies. A case study on the problems encountered by the farmers in adopting the sprinkler irrigation method in Sikar district, Rajasthan, conducted by the G.B. Pant University of Agriculture and Technology is given in **Annexure VIII.**

6.4 SEMINARS, WORKSHOPS AND TRAINING PROGRAMMES ON SPRINKLER IRRIGATION

In view of importance of the subject of sprinkler irrigation, a large number of seminars, workshops and training programmes were held in the country over the past 15 years. A list of these activities and some of the important recommendations made are given in **Annexure IX.**

Sprinkler System in Operating for Wheat Crop in Haryana.

CHAPTER 7

SPRINKLER SYSTEM AND ITS DESIGN

7.1 EVOLUTION OF SPRINKLER IRRIGATION SYSTEM

The sprinkler irrigation systems introduced at early stages were with hand moved laterals and rotating sprinklers. Later on with the growing need to save labour and water, solid set systems came into use. Further, carriage drive system with hose reel arrangement, giant sprinklers or gun sprinklers mounted on carriages, were developed to facilitate rapid coverage of large areas, mobile machines requiring minimum labour, were developed in the sixties and seventies, and at the same time, automation of various levels was introduced into sprinkler system in developed countries. Automation in its simplest form is achieved by using automatic metering valves, which are set to convey a desired volume of water and then shut off automatically. At a more advanced level, the valves could be operated in a pre-determined sequence. Even more sophisticated is the use of field control units to open and shut off the valves electronically according to a pre-set parameter such as soil moisture, soil temperature, etc.

7.2 TYPES OF SPRINKLER SYSTEM AND COMPONENTS

7.2.1 General Classification

Sprinkler systems are classified into the following two major types on the basis of the arrangement for spraying irrigation water.

a) Rotating head or revolving system.
b) Perforated pipe system.

a) Rotating head System

This can further be divided into three categories namely;

i) Conventional system/small rotary sprinklers,
ii) Boom type and self propelled sprinkler system, and
iii) Mobile rain gun/large rotary sprinkler

b) Perforated Pipe System

This method consists of drilled holes or nozzles along the length of the lateral pipe through which water is sprayed under pressures. This system is usually designed for relatively low operating pressure (<1.5 kg./sq.cm.). The application rate ranges from 1.25 to 5 cm per hour for various pressures and spacings. There are 3 types of spraying systems :

i) Stationary,
ii) Oscillating, and
iii) Rotating

7.2.2 Classification Based on Portability

Based on the portability, sprinkler systems are classified into the following types :

a) Portable system
b) Solid set or permanent system, and
c) Semi permanent system

Typical layout of portable sprinklers using one and two laterals are shown in Figures 7.1 and 7.2 respectively.

7.2.3 Components of Sprinkler Irrigation System

A typical sprinkler irrigation system usually consists of the following parts/components.

a) Pipe network - mains, sub mains and laterals,
b) Couplers,
c) Sprinkler head, and
d) Other accessories such as valves, bends, plugs, risers and fittings.

A Pumping unit is also required for pumping the water through the system.

In a typical sprinkler system, the breakup of costing is: pipe network 70%, couplers 15%, sprinkler heads 7% and other accessories 8%. In addition, the pumping and control unit costs about 40% of this total cost.

a) Pipe Network : The pipe network comprises generally of three types : main, sub main and laterals. Main pipe lines carry water from the pumping plant to many parts of the field. Sub main lines are provided to take water from the main to laterals. The lateral pipe lines then carry the water from the main or sub-main pipe line to the sprinklers. Sprinklers on a lateral pipe line may vary in number from one to thirty. The main pipe lines can be laid either as permanent, semi-permanent or portable ones. However, the lateral pipes are always laid as portable ones.

Permanent pipe lines are made of steel, asbestos, cement, plastic or wrapped aluminium. They are commonly buried at about 45 to 60 cm below ground level so as to be out of the way of farming operations. Portable pipe lines are usually made of aluminium or plastic (HDPE) and are generally equipped with quick coupling devices. These can be shifted quickly to enable farming operations.

b) Couplers : A coupler provides connection between two pipes and between pipes and fittings. Essentially a coupler should :

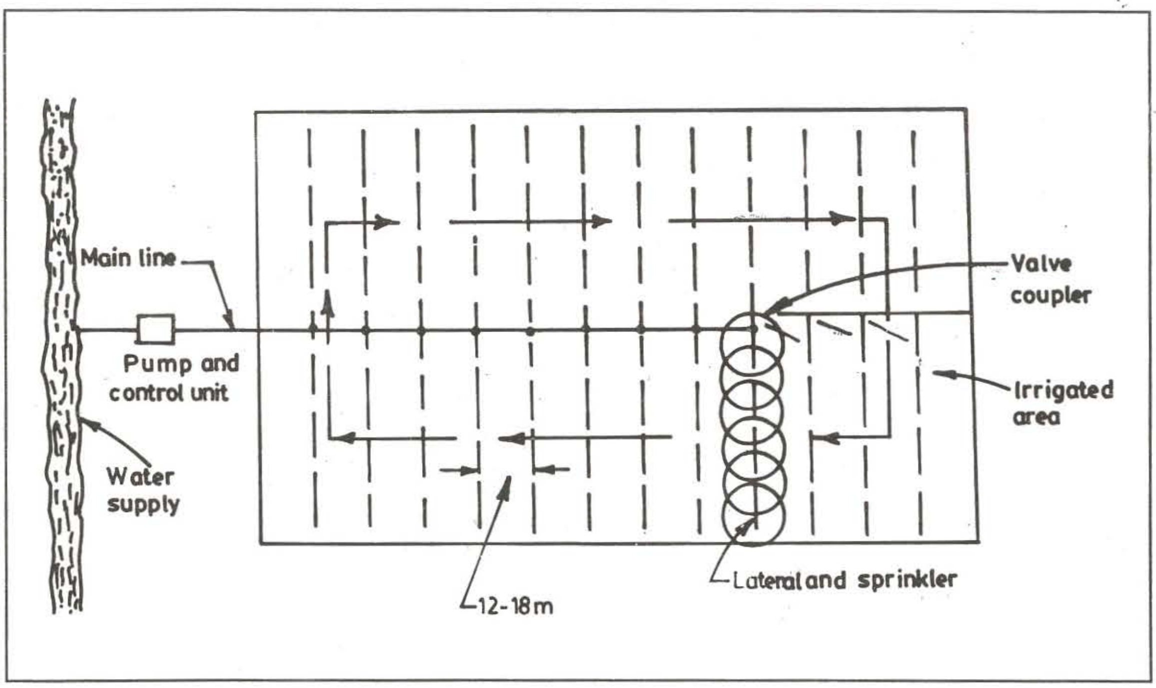


Fig. 7.1 Layout of Sprinkler Irrigation System for one lateral line.

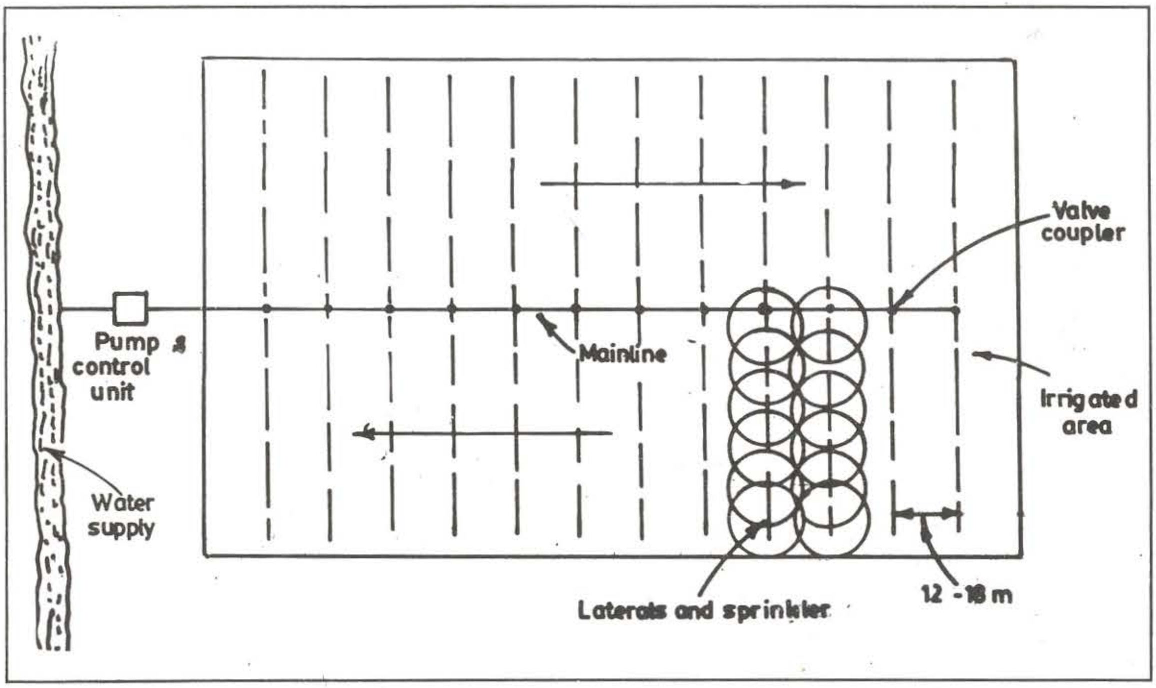


Fig. 7.2 Layout of Sprinkler Irrigation System for two lateral lines.

i) provide flexible connection,

ii) not leak at the joint under pressure,

iii) automatically drain at no pressure,

iv) be simple and easy to couple and uncouple, and

v) be light, non-corrosive, and durable.

c) Sprinkler Head or Sprinkler : Sprinklers may be rotating or fixed type. The components of a rotating sprinkler shown in Figure 7.3, can be adapted for a wide range of application rates and spacings. They are effective with pressures of about 1.5 to 4 kg/cm^2 at the sprinkler nozzle.

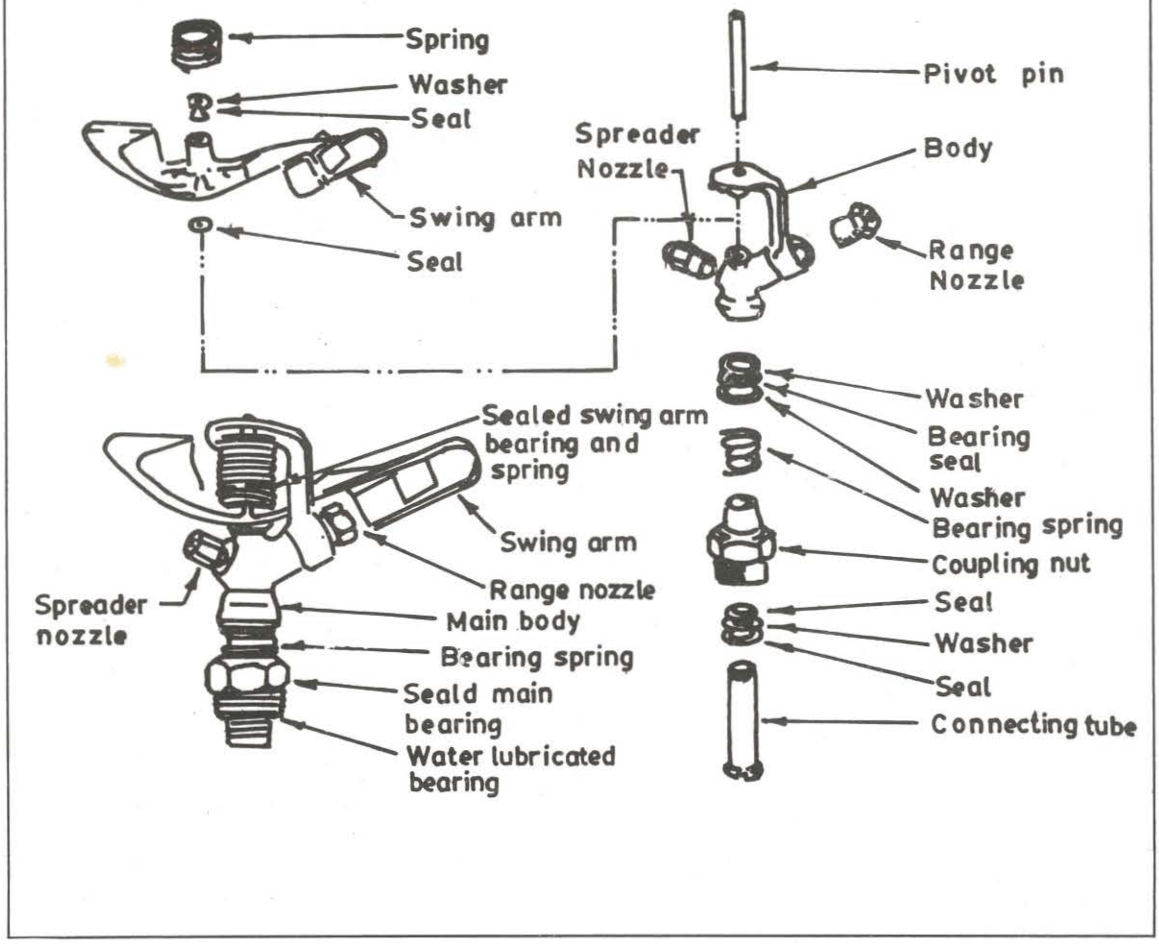


Fig. 7.3 Components of a rotary sprirkler head.

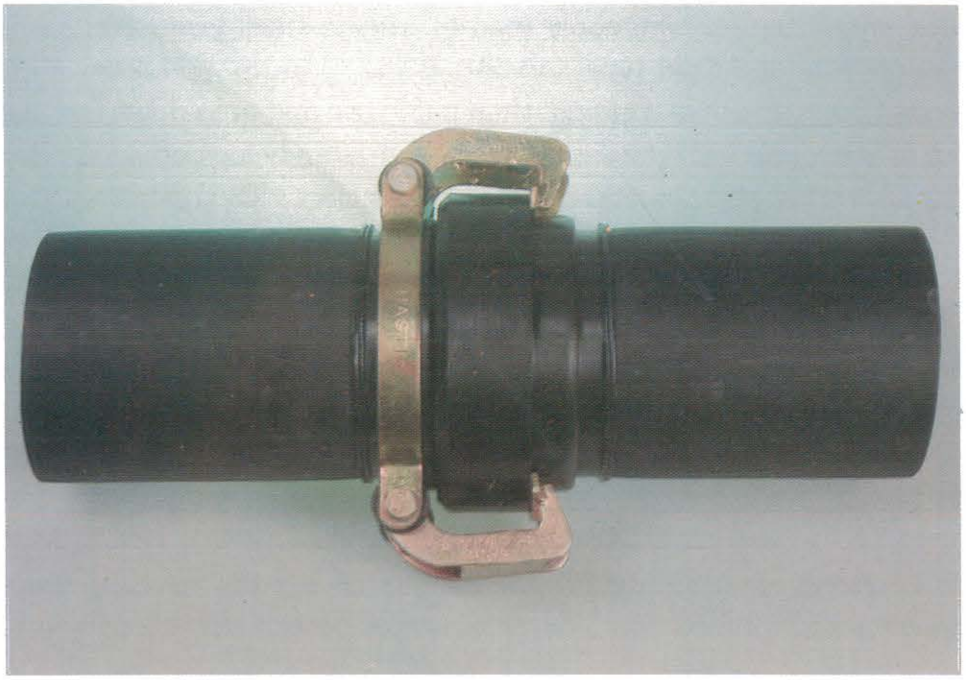


Fig. 7.4a HDPE quick coupler sprinkler system.

Fig. 7.4b HDPE quick coupler sprinkler pipes
(Courtesy : M/s Polyolefins Industries Limited)

Fixed type sprinklers are commonly used to irrigate small lawns and gardens. A recent variation of the fixed type sprinkler is the 'pop up' sprinkler. In this, the sprinkler unit pops up out of a casing when put to use and sinks down into the casing when not in use. This facilitates safety of the unit from being damaged. Perforated lateral pipe lines are also sometimes used as sprinklers. They require less pressure than rotating sprinklers. They also, release more water per unit of time than rotating sprinklers. Their use should be restricted to soils that have high intake rates.

d) Other Accessories/Fittings : To operate sprinkler system some fittings are essentially required while some are optional. The typical fittings are shown in Figs. 7.5, 7.6 & 7.7. Some of the important fittings/accessories used in a sprinkler system are Bends, tees, reducers, elbows, hydrants, risers, plugs and crosses, and butterfly valves. These are fabricated either from aluminum or HDPE, as the case may be depending upon the material of the pipe to suit the standard size of pipe. While drawing a bill of materials a designer should provide suitable couplers with all fittings.

7.3 PUMP AND CONTROL UNIT

Pump : To operate the sprinkler system sufficient pressure is required to distribute water under pressure to the fields. The pumping plant usually consists of a centrifugal or a turbine pump, a driving unit, a suction line and a foot value for the centrifugal system.

Centrifugal pump is generally used when the distance from the pump inlet to the water surface is less than eight metres. Normally centrifugal pumps are used to lift water from irrigation ditches, drainage canals, lakes, ponds river channels or shallow wells (Fig 7.8). If the distance to the water surface is more than eight meteres or if the water level is fluctuating widely, the use of a turbine pump is recommended. The driving unit may be either an electric motor or an internal combustion engine.

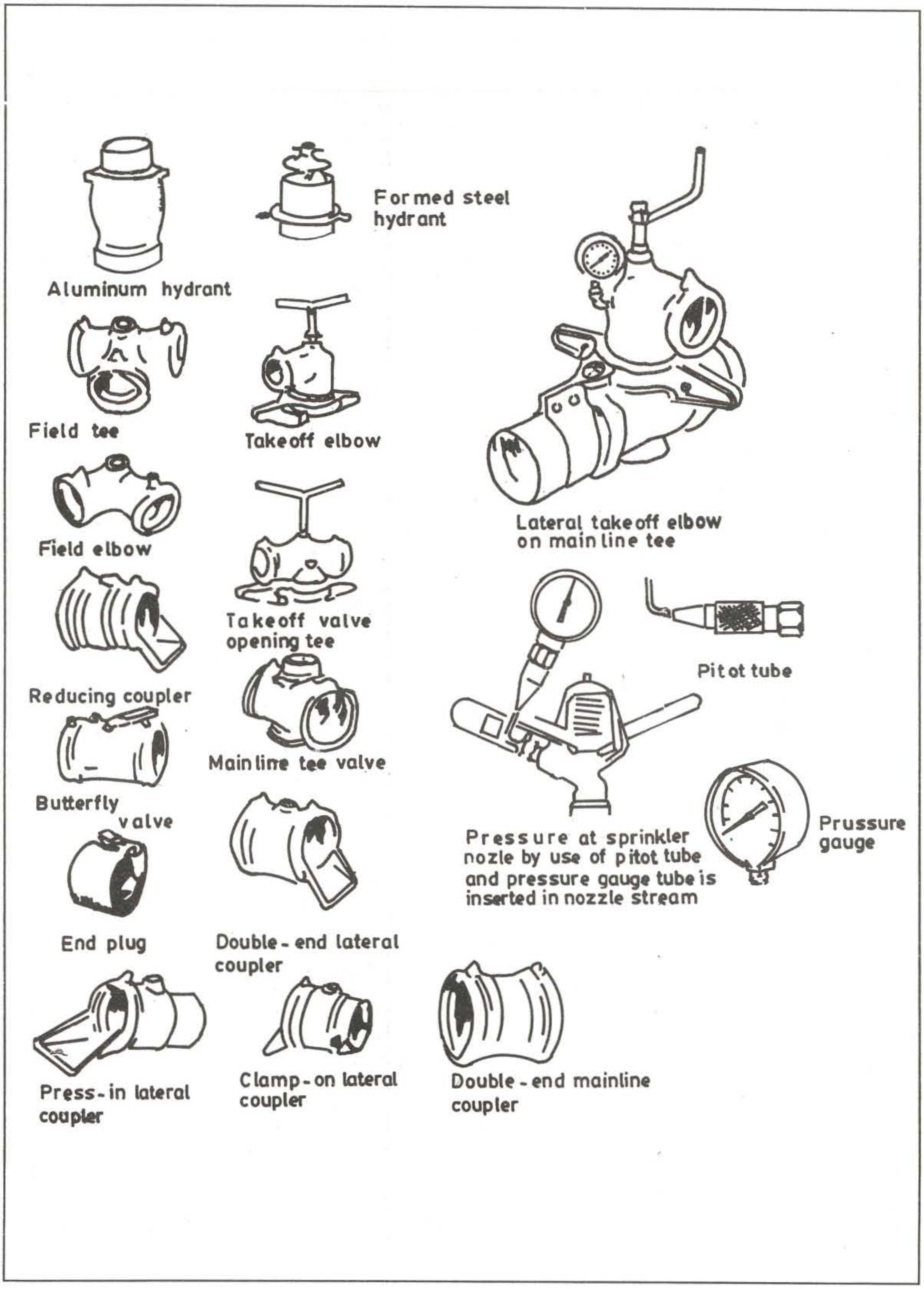


Fig. 7.5 Typical fittings of sprinkler irrigation system

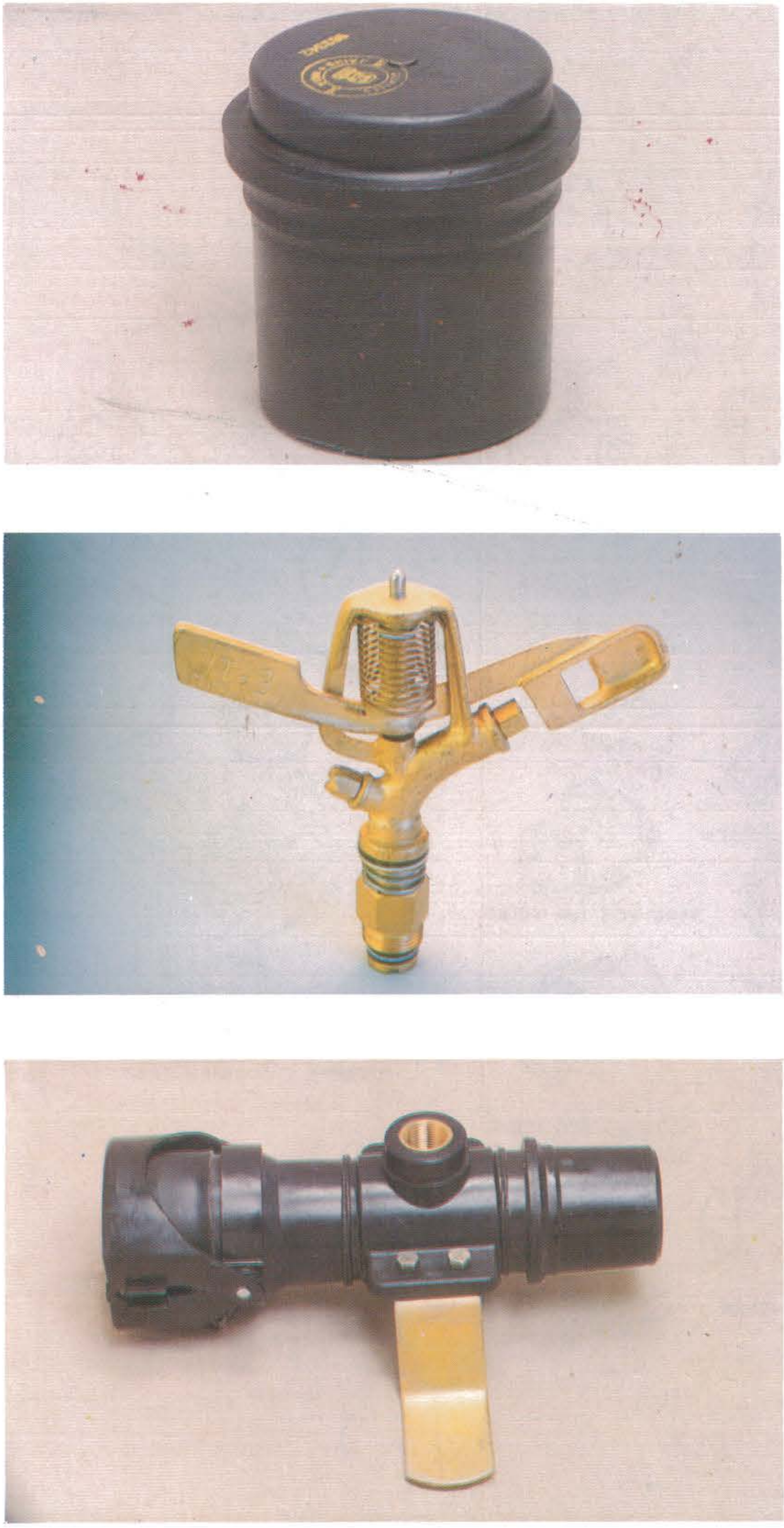


Fig. 7.6 Sprinkler fittings - 1
(courtesy : M/s Jain Irrigation Works)

Fig. 7.7 Sprinkler fittings - 2
(courtesy : M/s Jain Irrigation Works)

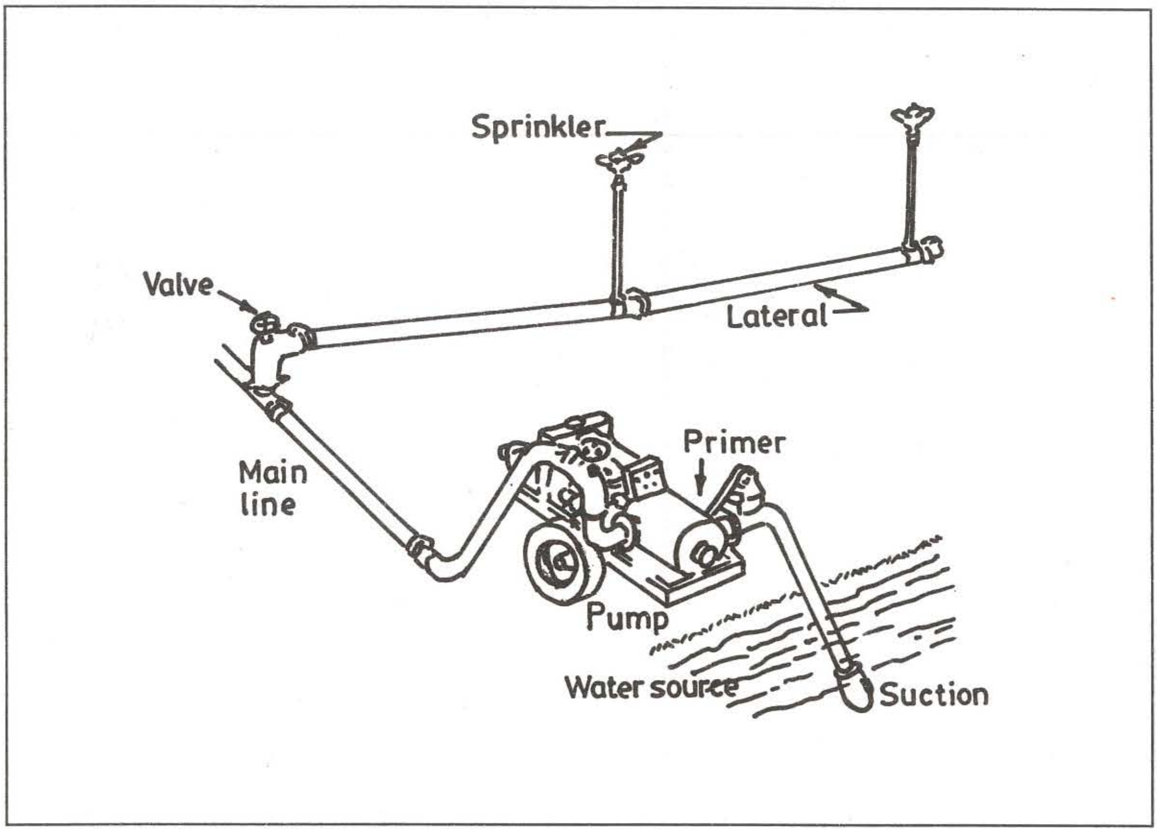


Fig. 7.8 Sprinkler irrigation system with a centrifugal pump.

Different types of pumps with desired characteristics, including monoblocks for sprinkler irrigation system are manufactured in India. Therefore, the farmers can select the pumpsets depending upon the soil, crop, slopes and discharge available and the pumping water level.

Water Meter : This is used to measure the volume of water delivered. In India, though irrigation water is normally not measured and users pay according to the area irrigated; this is necessary to operate the system to give the required quantity of water.

Pressure Gauge : It is used to measure and monitor the pressure under which the sprinkler is working in order to deliver the water uniformly. A portable gauge-pack with a pitot tube enables an operator to read the sprinkler pressure at the sprinkler nozzle which is in use.

Connectors : Flanges, couplings and nipples are used for facilitating proper connections to the pump and suction delivery pipes.

Fertilizer applicators : These are available in various sizes. They are used to inject fertilizers in liquid form to the sprinkler system at a desired rate. Continuous flow of water through the applicator is induced by slight difference in pressure at the two tapping points on the sprinkler system - one at the inlet end and the other at the outlet end. This facilitates sucking of fertilizer into the main system.

The objective of the design of sprinkler system is to obtain a system that provides satisfactorily uniform application of water with a minimum annual operation and maintenance cost. The design procedure should take into consideration crop requirements, existing soil type, climate, water quality and quantity, topography and shape of the field, irrigation facility, labour, economics and future expansion considerations.

The first step in the design of sprinkler systems is to make the resource inventory of the area. This includes

i) a map of the area,
ii) information on topography,
iii) climate, (rainfall, evaporation and wind etc),
iv) water source, its quantity, quality and period of availability,
v) crops grown and their characteristics such as effective root zone, peak consumptive use rate and its occurrence,
vi) soil characteristics such as infiltration rate water holding capacity, field capacity etc.,
vii) existing irrigation network, and
viii) plans for future expansion etc.

There is a general procedure involved in the planning and design of a sprinkler system which is given below (also see Fig. 7.11).

The depth of irrigation required (d, cm) is determined using the relationships :

Gross depth of irrigation : $d = D * d_m * s/E_a$

where,

D = Effective root zone depth of soil to be brought to field capacity, cm.

d_m = Difference in moisture content between field capacity and the moisture content before irrigation in percentage on dry weight basis.

s = Specific gravity of soil, and

E_a = Irrigation application efficiency.

Fig. 7.9 A close up view of measurement of nozzle pressure.
(Courtesy : P.D.C., Pantnagar)

Fig. 7.10 Measurement of discharge of sprinkler
(Courtesy : P.D.C., Pantnagar)

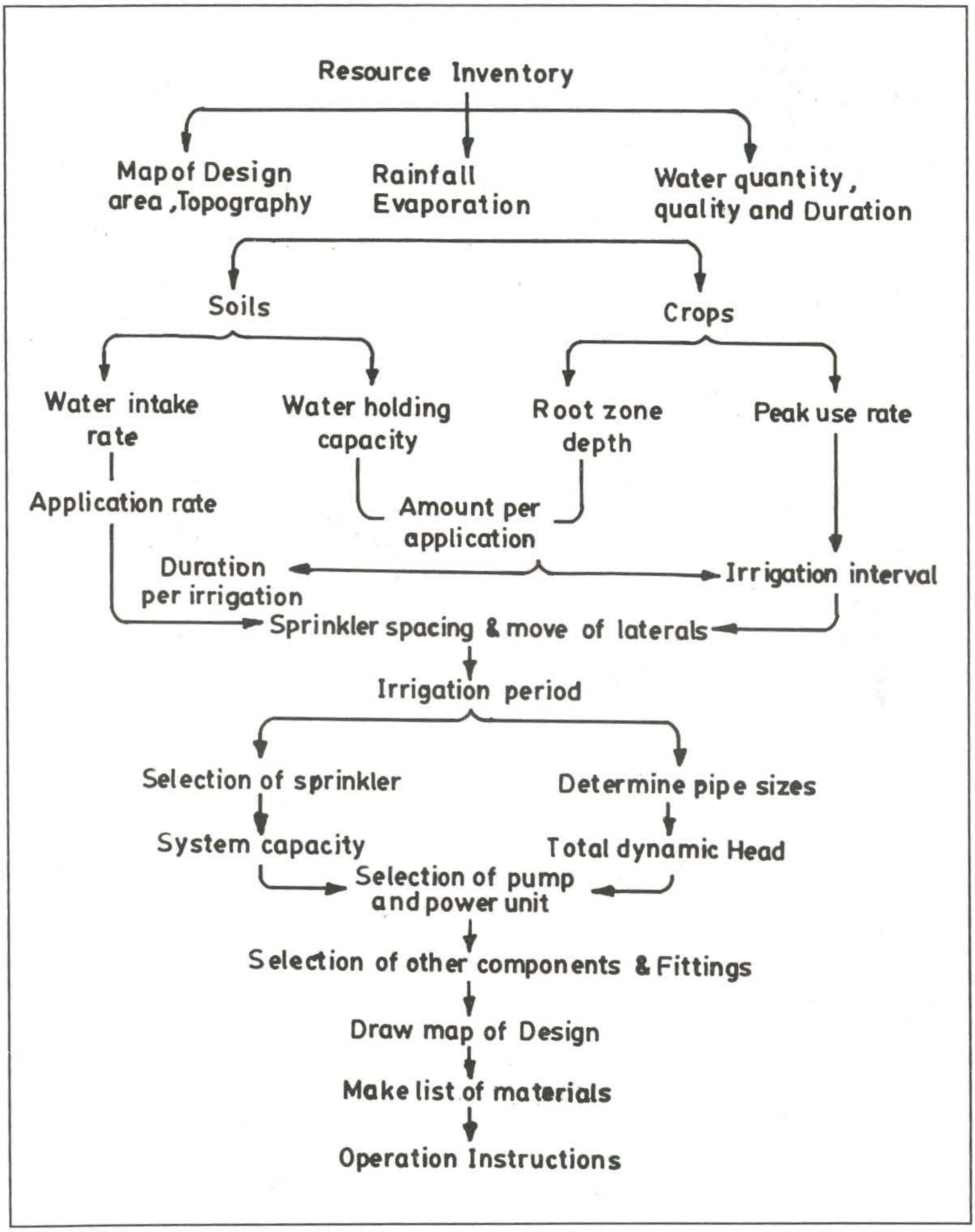


Fig. 7.11 Flow chart of the sequence of design of a sprinkler system.

b) Irrigation interval F (days) : The irrigation interval is expressed as :

$$F \text{ (days)} = \frac{\text{depth of irrigation (cm)}}{\text{Peak rate of daily consumptive use (cm/day)}}$$

c) Effect of Wind : To achieve uniform sprinkling of water, it is necessary to overlap water spread area of sprinklers. the overlap increases with the increase in wind velocity. Table 7.1 may be used as a guide in the design of sprinkler overlap under different wind conditions. The actual spacings, however shall be guided by the standard sizes of Pipes available in the market. Pipe sizes of 6 m (full size) and 3 m (half size) are generally available in the market.

Table 7.1
Maximum spacing of sprinklers under different wind conditions

Average wind speed	Overlap	Spacing
No wind	35%	65% of the diameter of the water spread area of a sprinkler head
0 to 6.5 km/hour	40%	60% of the diameter of the water spread area of a sprinkler head
6.5 to 13 km/hour	50%	50% of the diameter of the water spread area of a sprinkler head
Above 13 km/hour	70%	30% of the diameter of the water spread area of a sprinkler head

Source: Michael, A.M., 1978, Irrigation Theory & Practice, Vikas Publishing House, New Delhi.

d) Application Rate for Different Soils and Surface Slopes : The discharge of the sprinkler system would vary with the characteristics of the soil and its surface slope. The following information may be used to decide on water application rates for different soils and surface slopes. (Table 7.2).

Table 7.2
Suggested maximum application rate of sprinkler for different soils, surface slopes , (lps)

Soil texture & profile	Slope			
	0.5%	5-8%	8-12%	12-16%
Coarse sandy soil for 2 m depth	5.0	3.7	2.5	2.3
Coarse sandy soil over more compact soils	3.7	2.5	2.0	1.0
Light sand loams to 2 m	2.5	2.0	1.5	1.0
Light sandy loams over more compact soils	2.0	1.3	1.0	0.8
Silt loam to 2 m	1.3	1.0	0.8	0.5
Silt loam over more compact soils	0.8	0.6	0.4	0.3
Clay loam	0.4	0.4	0.2	0.1

Source: Michael, A.M., 1978, Irrigation Theory & Practice, Vikash Publishing House, New Delhi.

e) Selection of Sprinkler Nozzle : The sprinkler nozzle which gives application rate equal to or less than the infiltration rate of the soil is normally selected. The specifications of the sprinkler nozzle shall include model of sprinkler nozzle, nozzle size, diameter of throw, application rate and discharge of the nozzle.

f) Spacing of Sprinkler Nozzles : The spacing of sprinkler nozzles will depend upon nozzle size diameter of throw, and wind conditions. The values of maximum sprinkler nozzle spacing as a fraction of diameter of throw are shown in Table 7.3.

Table 7.3

Maximum allowable sprinkler nozzle spacing as a fraction of diameter of throw under conditions of wind.

Wind velocity in km/hour	Nozzle spacing in meters
0 - 6.5	0.6 x Diameter of throw
6.5 - 13.0	0.5 x Diameter of throw
13 or above	0.3 x Diameter of throw

Source: Plasticulture Development Centre, WTC, IARI, New Delhi

g) Number of Sprinkler Nozzles : Application rate of sprinkler nozzles (A,cm/hr)

$$A = \frac{360 \times \text{Discharge of nozzle (lps)}}{\text{(nozzle spacing,m)} \times \text{(lateral spacing, m)}}$$

The time needed to spray required depth of irrigation water by the sprinkler system (T, hrs),

$$T = \frac{\text{depth of irrigation (cm)}}{\text{Application rate of sprinkler nozzle (cm/hr.)}}$$

Number of sprinkler system shifts per day (n)

$$n = \frac{\text{Duration of pumping(hrs)/day}}{[(T \text{ (hrs)} + \text{shifting time hrs.})]}$$

Area to be irrigated per day :

$$a_1 = \frac{\text{Total area to be irrigated}}{\text{Irrigation interval}}$$

Area to be irrigated per Shift :

$$a_2 = \frac{a_1}{n}$$

Number of nozzles per shift : $\dfrac{a_2}{\text{area covered per nozzle}}$

rounded off to next higher integer.

h) Total Discharge of Sprinkler System : The total discharge, Q is given by :

Q (lps) = Discharge through one sprinkler nozzle x number of sprinkler nozzles

i) Layout of Sprinkler System : The field layout of sprinkler system is developed according to topography, location of water sources and the scheme of movement of lateral lines per day. The layout includes direction of laying of main and lateral lines from water source, and movement of lateral lines each day.

7.4.2 Selection of Size of Main Line, Lateral Line and Calculation of Friction Head Loss :

The sizes of main line and lateral line are selected as per the discharges carried through them and the friction loss corresponding to these discharges.
Discharge through lateral line

q = Sprinkler nozzle discharge x Number of sprinkler nozzles in one lateral line

Discharge through main line (Total discharge of sprinkler system)

Q = Sum of the discharges through all the laterals operating at any time.

The size or diameter of pipelines is selected by generally a trial and error procedure, by striking a balance between the cost of pipe and friction losses. Standard tables and charts are referred to for estimating friction losses for the given discharge, size, length of pipeline and number of nozzles used on the line. The step-by-step procedure is given below :

Step 1. Select a given size of pipe diameter.

Step 2. Assume the flow in the pipe through the entire length without sprinklers/ nozzles and determine the friction loss.

Step 3. Multiply the friction loss as in step 2 above by the correction factor (Table 7.4) obtained corresponding to the number of sprinklers on the lateral line.

Step 4. To step 3 above, add the elevation difference if the lateral goes uphill or subtract if it goes downhill.

Step 5. Check whether the head loss computed in step 4 is within the allowable limit of 20 percent of the operating head. If it is within the limit, the size of the pipe diameter selected in step 1 above is acceptable. Otherwise another value for the diameter of the pipe is selected and the steps 1 through 5 are repeated. When the value of head loss as obtained in step 4 is far less than the allowable value, then a smaller size of pipe, from among the available sizes, is considered. Otherwise, a larger size is adopted.

The friction loss in lateral lines can also be calculated with the help of Hazen William equation (for plastic pipes) and Scobey's formula (for Aluminum pipes). The friction loss calculated for lateral lines should be corrected with correction factor for multiple outlets (Table 7.4). An allowable pressure variation of 20 percent results in 10 percent loss/reduction in nozzle discharge, which is an acceptable norm for design.

Table 7.4
Correction factor (f) for computing friction loss in a pipe line with multiple outlets.

Number of Outlets	Value of 'f'	Number of Outlets	Value of 'f'
1	1.0	18	0.373
2	0.634	19	0.372
3	0.528	20	0.371
4	0.480	21	0.370
5	0.451	22	0.369
6	0.433	23	0.368

Contd....2.

Table 7.4 contd

Number of Outlets	Value of 'f'	Number of Outlets	Value of 'f'
7	0.419	24	0.367
8	0.410	25	0.366
9	0.402	26	0.365
10	0.396	27	0.364
11	0.392	28	0.363
12	0.388	29	0.362
13	0.384	30	0.360
14	0.381	35	0.359
15	0.379	40	0.357
16	0.377	50	0.355
17	0.375		

Source: Polyolefins Industries Limited, NOCIL, Akola.

7.5 SIZE OF PUMPING UNIT

The size of pumping unit depends on the total discharge carried through the system and total pressure head.

Total pressure head (H,m) = $H_f + H_o + H_s + H_r$

where,

H_f = Pressure head drop due to friction in lateral line + Pressure head drop due to friction in main line + Pressure head changes due to elevation of land surface (-/+) + friction head loss through fittings such as bends, Joints, etc., m,

H_o = Operating pressure head required at nozzle, m

H_s = Total static head, m

H_r = Height of riser,m, and

The required water horse power is calculated as :

WHP = $Q * H / 75$

Where,

Q = Total discharge, lps

H = Total head, m.

The horse power of the pump, HP is given by

HP = WHP / E_p x E_m

where,

E_p = Efficiency of pump

E_m = Efficiency of motor

7.6 EXAMPLE OF TYPICAL DESIGN OF A SPRINKLER SYSTEM.

1. Basic data for which the system is to be designed :

Area	:	10ha (length = 400 m x width = 250 m)
Topography	:	Leveled
Water Source	:	
Location	:	corner of the field,
Capacity	:	Adequate
Quality	:	Suitable for irrigation
Climate	:	Moderate

Ave. Wind speed : 4 km/hr.
No. of hours of pumping : 10 hrs/day,

Soil :

Type : Sandy loam
Infiltration rate = 2.50 cm/hr.
Apparent specific gravity = 1.5
Field capacity = 14%
Depth of effective root zone : 90 cm
Peak rate of daily consumptive use : 0.53 m/day
Moiture content before irrigration : 10%

Application efficiency : 85%

2. Calculations :

a) Depth of Irrigation

Gross depth of Irrigation

$$= \frac{90 \times (14-10^{*})}{100 \times 0.85} \times 1.5$$

$$= 6.35 \text{ cm}$$

b) Irrigation Interval

$$\text{Irrigation interval (days)} = \frac{6.35}{0.53}$$

$$= 11.98 \text{ days} \qquad \text{Say } 12 \text{ days}$$

c) Selection of sprinkler nozzle (refer manufacture's specifications (Table 7.5)

Normally High Pressure (HP) model is used for obtaining finer drop sizes for use with crops such as flowers, mustards, vegetables etc., which are likely to be damaged by the impact of the droplets. For the crop chosen (Mustard), an HP type nozzle is recommended.

Model	:	HP
Nozzle size	:	7.14 x 3.13 mm
Operating pressure	:	2.11 kg/cm^2
Diameter of throw	:	31.4 m
Application Rate	:	2.20 cm/hr.
Discharge of Nozzle	:	0.88 lps.

d) Spacing of Sprinklers

Referring to Table 7.1,

Nozzle spacing = 0.6 x Diameter of throw
= 0.6 x 31.4
= 18.84 or say 18 mtrs.

e) Spacing of Laterals

This depends upon the wind velocity. Normally upto a wind velocity of 6.5 km/hr, lateral spacing of 12 m is adopted. For higher wind velocities, the spacing is to be reduced to 6 m. Thus effective area covered per nozzle : 12 x 18 = 216 sqm. Accordingly, in the example case, the lateral spacing can be taken as 12 m.

f) Number of Sprinkler Nozzles

Application rate of Sprinkler Nozzle (cm/hr.)

$$= \frac{360 \times 0.88}{18 \times 12}$$

$$= 1.46 \text{ cm/hr.}$$

Time required to irrigate depth of irrigation by sprinkler system (hrs.)

$$T = 6.35/1.46 = 4.35 \text{ hrs.}$$
or 4 hrs. 21 minutes.

Number of Sprinkler system shifts per day

$$= \frac{10}{(4.35 + 0.5)}$$

$$= 2$$

Number of Sprinkler Nozzles

$$= \frac{10 \times 10^4}{2 \times 12 \times 216}$$

$$= 19.29 \; ; \quad \text{Say } 20 \text{ Nos.}$$

g) Total Discharge of the Sprinkler System

$$= 0.88 \times 20 = 17.60 \text{ lps.}$$

h) Layout of Sprinkler System.

The layout of the sprinkler system is as shown in Fig 7.12.

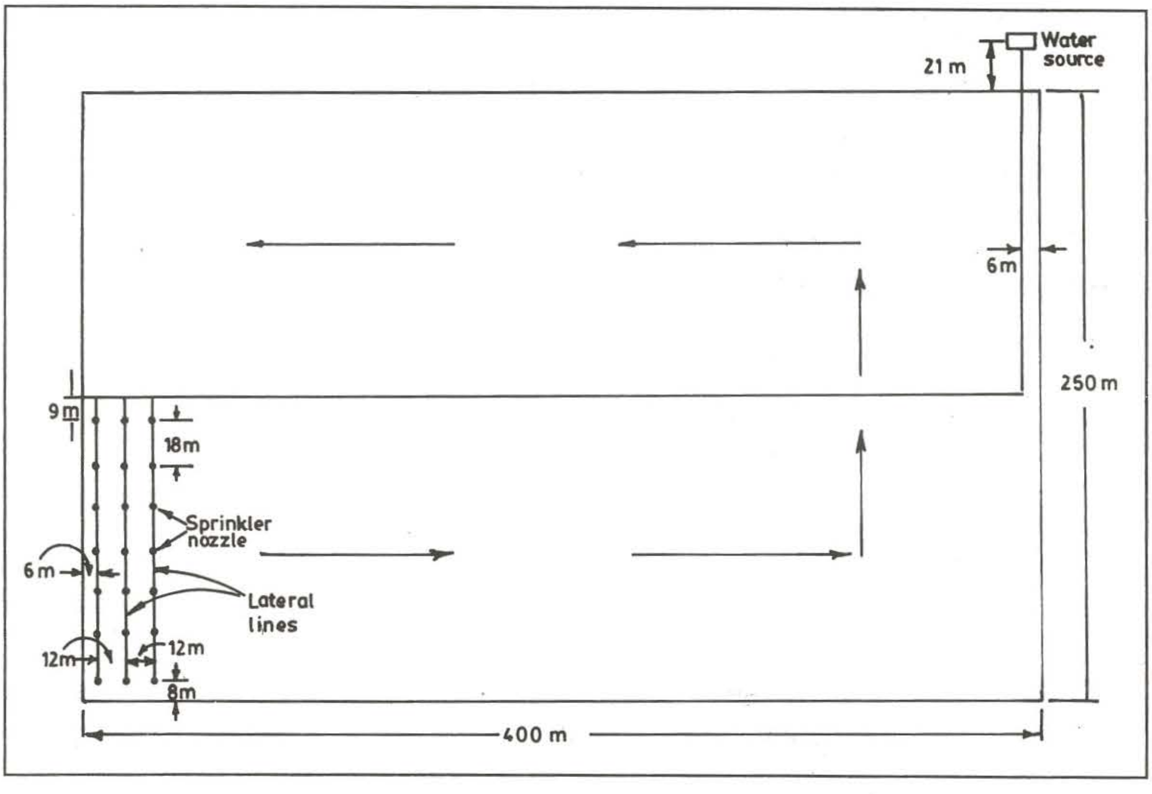


Fig. 7.12 Layout of sprinkler system

There will be three lateral lines each having 7 nos of sprinkler nozzles. The nozzle to nozzle spacing is 18 m and lateral to lateral spacing is 12 m. The movement of lateral lines are also shown in Fig. 7.11. The final discharge required after adjustment of sprinkler systems as per layout is 18.44 lps.

i) Selection of size of main line and lateral line & calculation of friction head loss.

Discharge through lateral line	=	0.88 x 7	=	6.16 lps.
Discharge through main line	=	0.88 x 21	=	18.48 lps.

Size of lateral line:

i. Trial size selected 75 mm diameter.

ii. Friction loss through the lateral line without outlets for a discharge of 6.16 lps (Table 7.6)

= 3.06 m x 1.07 (Adjusted for 6 metres pipe length)

= 3.27 m per 100 m

iii. Correction factor for 7 outlets (Table 7.4) = 0.419

iv. No elevation correction is required

v. Total friction head loss is

= 3.27 x 0.419 = 1.37 m per 100 m

The total length of each lateral is 117 m.

Total friction head loss in the lateral line

= Length of lateral line x friction head loss per m

= 117 x 1.37 /100 = 1.60 m

This is less than 20% of the operating pressure of 21 m.

Thus, the head loss is within the permissible limit.

Hence, the use of 75 mm pipe is appropriate.

Total friction loss in lateral lines : 1.60 x 3 = 4.80 m.

j. Selection of the Size of Main Line.

i. Select a size of 125 mm.

ii. Friction loss through main line for a discharge of 18.48 lps. (Table 7.6)

= 1.86 x 1.07 (Adjusted for 6 metres pipe length)

= 1.99 m. Per 100 m

iii. No elevation correction is required.

iv. Total friction head loss in main line of length (400 -2 x 6 + 125 + 21) = 534 m

(Adjusted to ensure the total length is a multiple of 6m)

= 89 pipe lengths of 6m each.

Friction loss in the main line

= Length of mainline x friction head loss

= 534 x 1.99/100

= 10.63 m

k) Size of Pumping Unit

Assume total static head	=	6 m
Height of rise	=	1 m
Pump efficiency	=	70%
Motor efficiency	=	70%
Total Pressure head	=	Friction loss in laterals + Friction loss in mainline + Operating head+static head+ Friction losses in fittings*+ height of the riser

Total pressure head = 4.80 + 10.63 + 21 + 6 +0.41* +1
= 43.84 m

* Assuming these losses to be of the order of 2% of the operating head.

$$HP = \frac{43.84 \times 18.48}{75 \times 0.7 \times 0.7} = 22.05 \text{ or Say } 25 \text{ HP.}$$

Thus, the salient features of the sprinkler system are :

1.	Depth of Irrigation	:	6.35 cm
2.	Irrigation Interval	:	12.0 days
3.	Sprinkler Nozzles	:	21 Nos.
	Size	:	7.14 x 3.13 mm
4.	Operating head	:	21 m (2.1 kg/cm^2)
5.	Discharge of nozzle	:	0.88 lps
6.	Spacing of nozzles	:	18 mtrs.
7.	No. of sprinkler system settings	:	2 per day
9.	Size of lateral	:	75 mm (dia)
10.	Size of main Pipe	:	125 mm (dia)
11.	Length of each lateral	:	117 m = 19 pipes of 6m each + 3m length/lateral
12.	Total length of laterals	:	57 full length+3 half length (Total 351 m)
13.	Length of main pipe	:	534 m = 89 pipe length
14.	Rating of pipe	:	4 kg/cm^2
15.	H.P. of the pump	:	25 H.P.

Table 7.5
Manufacturer's specifications

a. Performance characteristics of sprinkler nozzle model HP (High Pressure).

Nozzle Size	Pressure at sprinkler	Diameter of spray	Discharge	Appli. rate in inches per hours at spacing In Meters		
mm x mm	(kg/cm^2)	(m.)	(lps.)	12 x 12	12 x 18	18 x 18
7.11	2.04	25.5	0.56	0.55	0.37	-
x 3.13	2.38	29.1	0.62	0.61	0.41	-
	2.72	30.9	0.64	0.62	0.42	0.28
	2.11	31.4	0.88	-	0.49	0.33
	3.08	33.3	0.92	-	0.58	0.34
4.7	2.38	31.2	0.69	-	0.45	0.30
x 3.13	2.72	32.1	0.73	-	0.49	0.33
	2.11	33.6	0.85	-	-	0.37
	4.08	34.8	0.91	-	-	0.40

b. Performance characteristics of sprinkler nozzle model LP (Low Pressure)

Nozzle Size	Pressure at sprinkler	Diameter of spray	Discharge In meters	Appli. rate in inches per hours at spacing (Meters) 6 x 6	6 x 9	6 x 12	12 x 12	12 x 15
4.0 x 3.13	0.34	10.5	0.17	0.68	-	-	-	-
	0.68	14.1	0.23	0.90	0.60	-	-	-
	1.02	16.8	0.27	-	0.72	0.54	-	-
	1.36	19.2	0.31	-	-	0.82	0.62	-
	1.70	21.0	0.36	-	-	0.70	-	-
	2.04	22.5	0.40	-	-	-	0.39	-
	2.72	24.9	0.47	-	-	-	0.46	-
5.16 x 3.13	0.68	15.9	0.32	-	-	0.63	-	-
	1.02	18.6	0.39	-	-	0.76	-	-
	1.36	21.3	0.45	-	-	0.88	-	-
	1.70	23.7	0.50	-	-	-	0.49	-
	2.04	25.5	0.56	-	-	-	0.55	-
	2.72	28.2	0.65	-	-	-	0.64	0.51
5.6 x 3.13	0.68	16.5	0.35	-	-	0.69	-	-
	1.02	19.5	0.43	-	-	0.84	-	-
	1.36	22.2	0.49	-	-	-	0.48	-
	1.70	24.6	0.56	-	-	-	0.55	-
	2.04	26.7	0.61	-	-	-	0.60	-
	2.72	29.4	0.71	-	-	-	0.70	0.56

Source: Polyolefins Industries Limited, NOCIL, Akola.

Table 7.6
Friction head loss in irrigation pipes

Friction loss in metres per 100 m in lateral lines of portable aluminum pipe with couplings (based on Scobey's formula and 9 m pipe lengths) (adopted from Dr. A.M. Michael,1978)

Flow Lit/Sec	Diameter of Pipe				
	5 cm Ks 0.34	7.5 cm Ks 0.33	10 cm Ks 0.32	12.5 cm Ks 0.32	15 cm Ks 0.32
1	2	3	4	5	6
1.26	0.32				
1.89	2.53				
2.52	4.49	0.565	0.130		
3.15	6.85	0.858	0.198		
3.79	9.67	1.21	0.280		
4.42	12.90	1.63	0.376	0.122	
5.05	16.7	2.10	0.484	0.157	
5.68	20.8	2.63	0.605	0.196	
6.31	25.4	3.20	0.738	0.240	0.099
7.57		4.84	1.04	0.339	0.140
8.83		6.09	1.40	0.454	0.188
10.10		7.85	1.80	0.590	0.242
11.36		9.82	2.26	0.733	0.302
12.62		12.00	2.76	0.896	0.37
13.88		14.4	3.30	1.07	0.443
15.14		16.9	3.90	1.26	0.522
16.41		19.7	4.54	1.47	0.608
17.67		22.8	5.22	1.70	0.700
18.93		25.9	5.96	1.93	0.798
19.50		27.6	6.25	2.04	0.846
20.19		29.3	6.74	2.18	0.904
21.45		32.8	7.56	2.45	1.02
22.72		36.6	8.40	2.74	1.13
23.98		40.9	9.36	3.03	1.26
25.24		44.7	10.30	3.34	1.38
26.50			11.30	3.66	1.51
27.76			12.3	4.0	1.66
29.03			13.4	4.35	1.80
30.29			14.6	4.72	1.95
31.55			15.8	5.10	2.12
34.70			18.9	6.12	2.52
37.86			22.2	7.22	2.98
41.00			25.9	8.40	3.46
44.17			29.8	9.68	3.99
47.32			33.8	11.0	4.54
50.48				12.5	5.15
53.63				14.0	5.78
56.79				15.6	6.44
59.94				17.3	7.14
63.10				19.0	7.86

Table 7.7

Friction head loss calculations for HDPE main line based upon Hazen William equation with C = 150 for HDPE pipes

Internal Diameter/ Friction drop m/100m	48	57	64	71	76	84	93	104	112	119	126	136	143
0.10	0.334	0.523	0.714	0.940	1.153	1.480	1.962	2.609	3.178	3.710	4.26	75.27	16.059
0.11	0.355	0.551	0.752	0.989	1.214	1.558	2.065	2.747	3.346	3.906	4.492	5.549	6.379
0.12	0.372	0.577	0.788	1.037	1.272	1.633	2.165	2.879	3.507	4.094	4.708	5.816	6.686
0.13	0.388	0.603	0.823	1.083	1.328	1.705	2.260	3.007	3.662	4.274	4.916	6.073	6.981
0.15	0.404	0.627	0.856	1.127	1.382	1.774	2.353	3.129	3.811	4.449	5.117	6.321	7.266
0.16	0.434	0.674	0.920	1.211	1.486	1.907	2.529	3.363	4.096	4.782	5.499	6.793	7.809
0.18	0.449	0.697	0.951	1.252	1.535	1.971	2.613	3.475	4.232	4.941	5.642	7.020	8.069
0.19	0.477	0.740	1.010	1.329	1.630	2.093	2.775	3.690	4.494	5.247	6.034	7.454	8.569
0.21	0.503	0.781	1.066	1.403	1.721	2.209	2.929	3.895	4.744	5.538	6.369	7.868	9.044
0.24	0.528	0.820	1.120	1.473	1.807	2.320	3.076	4.091	4.983	5.817	6.690	8.264	9.500
0.26	0.553	0.858	1.171	1.541	1.891	2.427	3.218	4.280	5.212	6.085	6.998	8.645	9.937
0.29	0.588	0.912	1.245	1.639	2.010	2.580	3.421	4.550	5.541	6.469	7.440	9.190	10.56
0.31	0.621	0.964	1.315	1.731	2.123	2.726	3.614	4.807	5.854	6.834	7.867	9.710	11.16
0.35	0.652	1.013	1.383	1.820	2.232	2.865	3.799	5.053	6.154	7.184	8.262	10.21	11.73
0.38	0.683	1.060	1.447	1.905	2.336	2.999	3.976	5.289	6.441	7.519	8.648	10.68	12.28
0.42	0.722	1.121	1.530	2.013	2.469	3.170	4.203	5.591	6.608	7.948	9.141	11.21	12.98
0.46	0.759	1.178	1.609	2.117	2.597	3.333	4.420	5.879	7.159	8.358	9.612	11.87	13.65
0.51	0.804	1.247	1.703	2.241	2.749	3.529	4.679	6.223	7.578	8.847	10.17	12.57	14.45
0.56	0.846	1.313	1.793	2.359	2.894	3.715	4.926	6.552	7.979	9.314	10.71	13.23	15.21
0.61	0.895	1.389	1.896	2.495	3.060	3.929	5.209	6.928	8.438	9.850	11.33	13.99	16.09
0.67	0.941	1.461	1.994	2.264	3.219	4.133	5.480	7.288	8.876	10.36	11.92	14.72	16.92
0.74	0.993	1.541	2.104	2.769	3.397	4.360	5.782	7.690	9.365	10.93	12.57	15.53	17.86
0.81	1.043	1.619	2.210	2.908	3.567	4.579	6.071	8.075	9.834	11.48	13.20	16.31	18.75
0.90	1.097	1.703	2.325	3.060	3.753	4.817	6.388	8.496	10.85	12.08	13.89	17.16	19.73
0.98	1.156	1.794	2.449	3.223	3.953	5.075	6.729	8.950	10.90	12.72	14.63	18.08	20.78
1.08	1.218	1.891	2.581	3.397	4.166	5.348	7.091	9.432	11.49	13.41	15.42	19.05	21.90
1.19	1.283	1.992	2.720	3.571	4.390	5.636	7.472	9.939	12.10	14.13	16.25	20.08	23.08

Source: Michael, A.M., 1978, Irrigation Theory & Practice, Vikas Publishing House, New Delhi.

CHAPTER 8

BENEFITS, COSTS AND ECONOMICS

INTRODUCTION

Modern controlled irrigation systems like sprinkler systems are known to be harbingers of prosperity albeit heavy investment costs. The economic viability of adaptability of the sprinkler irrigation system needs to be established under varying conditions of soils, climate, terrain, crops to be grown, material to be used etc. In this chapter, the factors influencing the economic feasibility of the system, examples of analysis and some case studies are discussed.

8.1 BENEFIT COST ANALYSIS OF SPRINKLER SYSTEM

8.1.1 Capital cost of sprinkler system

The capital cost of sprinkler system depends on many parameters which are influenced by several factors such as proposed crop area to be irrigated, topography, soil type, water source, type of material used for the pipes, availability of energy at the location of use, etc. The factors listed above determine the following parameters which influence the capital cost.

Factors		Parameters
Crop	..	Water requirement at various growth stages
Soil	..	Infiltration rate (in turn selection of discharge, and irrigation interval)
Water source	..	Length of main and lateral pipes
Energy	..	Availability/duration to decide operational period/day and number of shiftings.
Topography of land	..	Total operating head to decide the HP of the pump
Type of material	..	High Density Polyethylene(HDPE) or Aluminium

The detailed bill of materials and the cost involved for sprinkler systems are given in Table 8.1. This cost estimate is exclusive of the cost of the pumping set. NABARD adopted these values.

Table 8.1

Detailed break-up of unit cost of HDPE sprinkler set for different land holdings

S.No.	Material	Unit Rate (Rs.)	1.5 Ha.		2Ha.		3Ha.		4Ha.	
			QTY (Nos)	AMT (Rs.)	QTY (Nos)	AMT (Rs.)	QTY (Nos)	AMT (Rs.)	QTY (Nos)	AMT (Rs.)
1.	75 mm dia * 6 Mt.Long Main Line HDPE pipe With Quick Action Coupler (Class of pipe 2-2.5 Kg/cm^2)	530	25	13250.00	30	15900.00	37	19610.00	45	23850.00
2.	75 mm Sprinkler Coupler with foot batten Assembly	370	5	1850.00	7	2590.00	11	4070.00	14	5180.00
3.	Sprinkler Nozzles (Pressure 1.7 to 2.8 Kg/cm^2)	375	5	1875.00	7	2625.00	11	4125.00	14	5250.00
4.	20 mm dia X 76 cm Long Riser pipe (GI)	65	5	325.00	7	455.00	11	715.00	14	910.00
5.	Connecting Nipple	260	1	260.00	1	260.00	1	260.00	1	260.00
6.	Rend with Coupler	350	1	350.00	1	350.00	1	350.00	1	350.00
7.	Tee with Coupler	430	1	430.00	1	430.00	1	430.00	1	430.00
8.	End Plug (75 mm)	100	2	200.00	2	200.00	2	200.00	2	200.00
Total				18540.00		22810.00		29760.00		36430.00
SAY (Rs.)				18500.00		22800.00		29800.00		36500.00
Cost/ha				12350.00		11400.00		9950.00		9125.00

Irrigation Cycle : Once in 5 to 6 days Operating time : 6hrs per day

Source : National Agricultural Bank for Rural Development (NABARD)

It is seen that the estimated cost for 1.5 ha is Rs.18,540/- and for 4 ha. it is Rs.36,430/- Since the sprinkler system can be shifted 2 to 4 times in a day, the cost becomes comparatively less when the area is large.

8.2 RESEARCH STUDIES OF ECONOMIC ANALYSIS

Experiments conducted for groundnut in Gujarat Agricultural University indicated that the highest net return of Rs.9562/- was accrued with the sprinkler irrigation (treatment of 0.75 IW/CPE ratio) and the saving of water was about 20% compared to traditional gravity irrigation. The net income per mm of water used was more under the sprinkler irrigation over check basin method of irrigation.

Studies for wheat crop, confirmed the superiority of sprinkler over other gravity methods both in terms of water saving as well as increase in yield. The studies at Navasari revealed that the net income was (for 0.75 IW/CPE) Rs.1268/-per ha. more than that of the conventional surface irrigation method. The savings of irrigation water ranged from 41 to 49% corresponding to the values of IW/CPE ratio of 0.75 and 0.6 respectively. With the water saved, an additional 0.97 and 0.70 ha of land could be cultivated which finally resulted net additional income of Rs.6000 and Rs.4000 respectively. Results of economic analysis of adoption of sprinkler irrigation system for various crops are listed in **Annexures X & XI.**

Economic feasibility of sprinkler irrigation system has been investigated for maize, wheat crop rotation by the Rajasthan Agricultural University. The study showed that the benefit cost ratio ranged from 2.0-2.5 for the HDPE and alluminum based systems.

8.3 CASE STUDY OF BENEFIT COST ANALYSIS.

Cost Analysis

The cost component of benefit cost analysis consists of both direct and indirect costs. Direct costs are influenced by the following parameters :

- Area to be irrigated
- Total working hours of sprinkler system during the growing season
- Electricity charges (number of electricity units consumed)
- Expenditure on work charges
- Running costs, and
- maintenance etc.

Indirect costs include interest (@ 10 %) and depreciation (@ 10%) on the capital cost of sprinkler system. Benefit from the sprinkler irrigation system includes additional crop yield leading to additional income. The ratio of the benefit derived and the total cost (including direct and indirect costs) is the benefit cost ratio.

The case study under consideration for benefit cost analysis is on canal irrigation based sprinkler system. The installation of sprinklers in canal command area in the arid and semi arid areas in its south west region of Haryana State started during the late seventies. Sprinkler irrigation systems were installed on Jui feeder, Jui canal and Sewani canal. The installation of sprinkler systems were prompted by water scarcity and high percolation losses of irrigation water due to sandy terrain. The conventional surface irrigation methods were ineffective. The detailed economic analysis studies were conducted for 16 sprinkler sets for the year 1992-93. The specific details of the study are described for one sprinkler set on Jui feeder in the following paragraphs. Information of various parameters taken for the study for the other 15 sprinkler sets are shown in Table 8.2.

Case study of Sprinkler Irrigation System on Jui Feeder, Haryana

General Details

Date of Installation of sprinkler system	:	September, 1990
Date of Energisation	:	September, 1990
Capital cost of sprinkler set	:	Rs.169,000
Area of the chalk to be irrigated	:	44 hectares
Area under *kharif* crops	:	9.2 hectares
Size of pumpset used for pumping	:	15 H.P.
Discharge of pumping set	:	10.95 lps.
Crops grown during *kharif* season	:	Bajra (4.8 ha) Jowar (1.2 ha) Cotton (3.2 ha)
Crops grown during *rabi* season	:	Wheat (6.4 ha) Barley (1.0 ha) Mustard(2 ha) Gram (15.2 ha)
Total working hours of sprinkler system for irrigating *kharif* crops		305 hrs
rabi crops		1056 hrs.

Cost component

i. Direct cost

a) Electricity charges[@]	*kharif*	:	Rs. 3290
	rabi	:	Rs. 3570
	Total	:	Rs. 6840

@ This is based on Average number of units of electricity consumed by 10 h.p. motor and accordingly, the number of unit consumed in *kharif* & *rabi* season are 2530 and 9900 respectively.

b) <u>Operating , maintenance and Repair costs</u>

kharif	:	-
rabi	:	Rs. 928
Total	:	Rs. 928

c) <u>Expenditure on work charges</u>

kharif	Rs. 23945
rabi	Rs. 24250
Total	Rs. 48195

Total direct cost = a + b + c

kharif	Rs. 27215
rabi	Rs. 28748
Total	Rs. 55963

ii. Indirect cost

a) Interest @ 10% per annum or 5% per season

kharif	Rs. 8450
rabi	Rs. 8450
Total	Rs.16900

b) Depreciation on capital cost @ 10% annual or 5% per season

kharif	Rs. 8450
rabi	Rs. 8450
Total	Rs. 16900

Total indirect cost = a+ b

kharif	Rs. 16900
rabi	Rs. 16900
Total	Rs. 33800

Total cost = Direct + Indirect cost

kharif	Rs. 44115
rabi	Rs. 45648
Total	Rs. 89763

Benefit derived from sprinkler system installation

Additional benefit due to installation of sprinkler system for

	Crops	Amount
kharif season		
	Bajra	Rs. 2800/ha
	Jowar	Rs. 4000/ha
	Cotton	Rs. 24500/ha
rabi season		
	Wheat	Rs. 5375/ha
	Barley	Rs. 5375/ha
	Mustard	Rs. 1081.65/ha-
	Gram	Rs. 9600/ha

Total additional benefit due to produce

kharif Rs. 1120 x 4.8 + 1600 x 1.2 + 9800 x 3.2 = Rs.96,640

rabi Rs. 2150 x 6.4 + 2150 + 4320 x 2 + 3840 x 15.2

= 210,520

Benefit cost Ratio

kharif	2.19:1
rabi	4.61:1

Table 8.2
ANNUAL DATA OF SPRINKLER SETS FOR THE YEAR 1992-93

Sl. No.	Description	JUI FEEDER					JUI CANAL					SEWAN CANAL				
		RD 157000-L	RD 150500-L	RD 152000-L	RD 154200-L	RD 156000-L	RD 1000-L	RD 6750-L	RD 12150-R	RD 79800-L	RD 82780-L	RD 40250-L	RD 49000-R	RD 53200-R	RD 64020-R	RD 68500-L
1.	Date of Installation	6/78	9/90	9/90	1/90	11/89	1/76	8/79	8/79	8/79	6/78	11/87	10/86	10/86	7/87	10/87
2.	Date of Energisation	9/78	9/90	9/90	1/90	11/89	6\76	11/79	11/79	9/80	9/78	11/87	10/86	10/86	7/87	10/87
3.	Capital cost of Str.set	101883	169000	155000	159300	164000	105000	84843	51982	67532	67532	227110	250340	109358	266000	240913
4.	H.P. of motor	12.5	15	20	15	15	20	12.5	7.5	10	10	25	15	15	175	25
5.	Discharge of pumping set	145	146	225	145	148	226	186	116	137	137	240	175	150	201	233
6.	Rainfall per hour in cm	1.12	1.12	1.12	1.12	1.12	1.22	1.29	1.29	1.12	1.12	1.24	1.12	1.12	1.14	1.02
7.	Size of chak	102	110	126	111	108	165	138	86	102	102	140	105	98	117	136
8.	Irrigation in ha.															
	kharif	25	57.5	52.5	100	27.5	10	10	15	20	17.5	-	27.5	40	12.5	37.5
	rabi	162.5	157.5	162.5	312.5	162.5	122.5	110	117.5	30	167.5	85	252.5	240	265	185
	Total	187.5	215.0	215	412.5	190	132.5	120	132.5	50	185	312	280	280	277.5	222.5
9.	Working hours															
	kharif	239	305	321	506	203	40	58	232	153	535	237	679	539	-	373
	rabi	640	1056	864	1319	1002	720	872	835	855	820	1289	1660	1314	839	437
	Total	879	1361	1185	1825	1205	760	930	1067	1008	1355	1526	2339	1844	839	810

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Table 8.2 contd..

Sl. No.	Description	JUI FEEDER					JUI CANAL					SEWAN CANAL				
		RD 157000-L	RD 150500-L	RD 152000-L	RD 154200-L	RD 156000-L	RD 1000-L	RD 6750-L	RD 12150-R	RD 79800-L	RD 82780-L	RD 40250-L	RD 49000-R	RD 53200-R	RD 64020-R	RD 68500-L.
10.	Revenue Receipt															
	Kharif	393	921	827	1722	422	221	217	270	379	268	1506	494	486	222	760
	Rabi	1854	1992	2044	4383	2483	1517	1306	1760	364	2098	2262	3465	2903	3736	2407
	Total	2247	2913	2871	6105	2905	1738	1523	2030	743	2366	3768	3958	3389	3958	3167
11.	Electricity Charges															
	Kharif	3582	3270	4260	3270	3270	4280	2670	1537	2260	2260	4300	2950	2550	2550	2550
	Rabi	3516	3570	4680	3570	3570	4680	3045	1875	2460	2460	6020	4130	3570	3570	3570
	Total	7098	6840	8940	6840	6840	8960	5715	3412	4720	4721	10320	7080	6120	6120	6120
12.	Direct Running Repair															
	Kharif	2027	-	-	-	-	4901	-	-	-	-	-	-	-	-	-
	Rabi	7148	928	1855	3453	-	910 0	1623	-	696	928	-	-	-	-	-
	Total	9175	928	1855	3453	-	14001	1623	-	696	928	-	-	-	-	-
13.	Expenditure On work charges															
	Kharif	19430	23945	23945	23945	23945	19600	19250	19250	19420	18700	12410	12400	12400	12510	12400
	Rabi	19250	24250	24250	24250	24250	20055	19430	19430	19530	19130	17360	17360	17365	17470	17360
	Total	38680	48195	48195	48195	48195	39655	38680	38680	38950	37830	29770	29770	29765	29980	29760
14.	Indirect Interest @ 10% average @ 5%															
	Kharif	5094	8450	7750	7950	8200	5250	4242	2599	3377	3377	11356	12517	5468	13300	12046
	Rabi	5094	8450	7750	7950	8200	5250	4242	2599	3377	3377	11356	12517	5468	13300	12046
	Total	10188	16900	15500	15900	16400	10500	8484	5198	6754	6754	22712	25034	10936	26600	24092

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Table 8.2 contd..

Sl. No.	Description	JUI FEEDER					JUI CANAL					SEWAN CANAL				
		RD 157000L	RD 150500L	RD 152000L	RD 154200L	RD 156000L	RD 1000L	RD 6750L	RD 12150R	RD 79800L	RD 82780L	RD 40250L	RD 49000R	RD 53200R	RD 64020R	RD 68500L
15.	Expendi-	ture depreciation @ 10% Average 5%														
	Kharif	5094	8450	7750	7950	8200	5250	4242	2599	3377	3377	11356	1251	5468	13300	12046
	Rabi	5094	8450	7750	7950	8200	5250	4242	2599	3377	3377	11356	12517	5468	13300	12046
	Total	10188	16900	15500	15900	16400	10500	8484	5198	6754	6754	22712	25034	10936	26600	24092
16.	Total Ex-	penditure Direct & Indirect charges														
	Kharif	35227	44115	43705	43115	43615	39281	30404	25985	28434	27714	39422	40384	25880	41660	39042
	Rabi	40102	45648	46285	47173	47673	44335	32582	26503	29440	29272	46092	46524	31871	47640	45022
	Total	75329	89763	89990	90288	91288	83616	62986	52488	57874	56986	85514	86908	57757	89300	84064
17.	Cost of	Irrigation per acre														
	Kharif	3523	1918	2081	1077	3965	9820	7601	4330	3554	3959	1159	3671	1617	8332	2603
	Rabi	617	724	712	377	733	905	740	564	2394	436	368	460	332	449	608
18.	Average	cost of Irrigation														
		2070	1321	1396	727	2349	5362	4170	2447	2974	2197	764	2065	975	4390	1606

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Sl. No.	Description	JUI FEEDER					JUI CANAL					SEWAN CANAL				
		RD 157000-L	RD 150500-L	RD 152000-L	RD 154200-L	RD 156000-L	RD 1000-L	RD 6750-L	RD 12150-R	RD 79800-L	RD 82780-L	RD 40250-L	RD 49000-R	RD 53200-R	RD 64020-R	RD 68500-L
19.	No. of Units consumed. Average 10 H.P.															
	Kharif	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530
	Rabi	9900	9900	9900	9900	9900	9900	9900	9900	9900	9900	9900	9900	9900	9900	9900
20.	*Kharif*															
	Jowar @ 4000/- Per. Acre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Bajra @ 2800/- Per.Acre	-	12	6	6	5	-	-	1	2	3	-	-	-	-	-
	Jowar @ 2400/- Per.Acre	5	3	9	19	5	-	-	-	1	-	8	-	4	-	-
	Cotton@24500/- Per.Acre	5	8	515	1	4	4	5	5	4	18	3	-	3	14	
	Other @ 2800/- Per.Acre	-	-	1	-	-	-	-	-	-	-	8	8	12	2	1
	Total	10	23	21	40	11	4	4	6	8	7	34	11	16	5	15
21.	*Rabi*															
	Wheat @ 5375/- acre	8	16	19	35	7	-	2	6	-	2	20	15	11	9	16
	Barley @ 5375/- Per.acre	8	4	-	-	7	-	-	-	2	1	-	-	-	-	-
	Sarson@ 1080/- Per.acre	-	5	7	14	30	14	4	39	-	36	24	59	14	23	22
	Gram @ 9600/- Per. acre	56	38	39	75	21	35	36	2	10	28	81	27	71	74	36
	Others@ 5375/- Per.acre	1	-	-	1	-	-	2	-	-	-	-	-	-	-	-
	Total	65	63	65	125	65	49	44	47	12	67	125	101	96	106	74

Contd...

Table 8.2 contd..

Sl. No.	Description	JUI FEEDER					JUI CANAL					SEWAN CANAL				
		RD 157000L	RD 150500-L	RD 152000-L	RD 154200-L	RD 156000-L	RD 1000L	RD 6750L	RD 12150R	RD 79800L	RD 82780L	RD 40250L	RD 49000R	RD 53200-R	RD 64020-R	RD 68500L
22.	Working hours per ha Irrigated															
	kharif	60	38.15	38.2	31.63	41.13	25.00	30.00	91.5	97.80	191.05	16.43	154.30	82.8	-	-
	rabi	24.6	41.9	33.23	26.38	38.53	36.73	49.53	44.4	178.13	30.78	25.78	37.05	34.2	19.78	14.75
23.	Intensity of Irrigation															
	kharif	9.60	20.90	16.66	36.03	10.18	2.52	2.70	6.57	7.64	6.86	24.28	10.47	16.32	4.27	11.02
	rabi	63.72	57.27	51.58	112.61	60.01	25.69	31.88	54.65	11.96	65.68	85.28	96.19	97.95	5.59	54.41
24.	Additional Benefit due to produce															
	kharif	57000	96640	41240	184120	23400	39300	39200	50120	52840	42560	198160	36660	19840	31640	138320
	rabi	234390	210520	262090	425880	240340	194880	164120	189060	42700	269480	457720	390810	356770	402870	267680
25.	Benefit cost Ratio															
	kharif	1.62:1	2.19:1	0.94:1	4.27:1	0.54:1	0.99:1	1.29:1	1.92:1	1.86:1	1.53:1	5.02:1	0.95:1	0.77:1	0.76:1	3.54:1
	rabi	5.84:1	4.61:1	5.66:1	9.02:1	5.04:1	4.40:1	5.04:1	7.13:1	1.50:1	9.20:1	9.83:1	8.40:1	11.19:1	8.46:1	5.94:1
26.	Average Benefit cost Ratio	5.73:1	3.40:1	3.30:1	6.64:1	2.79:1	2.69:1	3.16:1	4.53:1	1.68:1	5.36:1	7.42:1	4.67:1	5.98:1	4.61:1	4.74:1

Source : S.K. Dua, Chief Engineer, Irrigation Department, Haryana, Personal Communication

HDPE sprinkler system

CHAPTER 9

INFRASTRUCTURAL REQUIREMENTS

The adaptability of sprinkler irrigation system is well recognized by the farmers and there is a great need and scope for adopting sprinkler irrigation in a big way. There are many problems and constraints in adopting the technology. To promote the use of sprinkler system a definite role has to be played by the various agencies such as Central and State Governments, policy makers, manufacturing firms, financial institutions, research organizations and farmer's associations. A brief account of the roles to be played by these agencies is discussed in this chapter.

9.1 CONSTRAINTS

There is no second opinion about the potential and prospects of sprinkler irrigation method to improve the effective use of irrigation water particularly in water scarce regions, and to increase the agricultural production, but the problem is how to implement it in a big way. The challenge has to be met through multi pronged efforts. Though the farmers are increasingly aware of the need to change the traditional method of irrigation for securing higher productivity and better water use efficiency, they have encountered various problems and constraints. Unless these barriers are broken and efficient methods of irrigation adopted, sustained agriculture cannot be realized.

The Central and State Governments are very keen in bringing more area under sprinkler system. The banks and credit institutions are interested in providing loan facilities to the farmers for purchase of the equipment. The farmers are also inclined to go for the water saving method of irrigation for achieving higher levels of production on a sustained basis. Several universities and research organisations are also undertaking research to provide more information about water requirements, reducing cost of the systems etc.

There are a large number of manufacturers/companies/firms dealing with sprinkler irrigation in the country **(Annexure-XII).** Some have collaboration with leading manufacturers of sprinkler system in the world. Therefore, there will not be any problem in introducing this method in large scale in the next 10-15 years. But, it requires detailed and phased plans by the Government and manufacturers and determination in the minds of the farmers. However, this is not bereft of constraints. Some of the constraints/impediments encountered and possible remedies are as follows :

S No.	Constraints	Remedies
1.	High Initial Cost	Subsidy support, loan at concessional rate, reduction in duties & taxes, mass production of the system components.
2.	Quality of Material	Adoption of standards without increasing the cost and compromising the technology.
3.	Availability of Uninterrupted Power Supply	Efforts to enhance the availability of power in rural sector, through alternate renewable sources.
4.	Lack of adequate technical inputs of design, installation and after Sale Service	Layout and design should be standardized to reduce the cost of the system. Farmers should be given training to attend to day to day problems.
5.	Need of skilled labour	Rural unemployed youth may be provided training in the operation and maintenance of sprinkler systems.
6.	Availability of Components	The manufacturers should ensure regular supply of components and spares through dealer network.
7.	Unsatisfactory implementation of subsidy scheme	The Central/State Government should adopt appropriate measures to monitor and effectively implementing the schemes.
8.	Insufficient extension services	The focused efforts of the Government, manufacturers and other promotional agencies are required in a mission made.
9.	High Cost due to excise and other taxes	The Government may consider abolishing the excise and other taxes on this system to reduce the cost.

9.2 ROLE OF VARIOUS AGENCIES/ORGANIZATIONS

9.2.1 Central and State Governments

Government Support for Sprinkler System :

The Ministry of Agriculture (GOI) has been providing subsidy support for Sprinkler irrigation since VII plan under the scheme on National Pulse Development Project (NPDP) and Oil seeds & Pulses Production (OPDP). The scheme was continued during the VIII plan. The pattern of subsidy for sprinkler sets followed in 1992-93 was @ 50%, 75%, and 25% of the cost for small and marginal farmers, SC/ST farmers and for those belonging to other categories , respectively, subject to a maximum of Rs. 10,000/- per set in all cases. This was subsequently revised, while approving the continuation of the schemes on NPDP & OPDP during VIII plan. The revised pattern approved was at the rate of 50% of the cost for small and marginal farmers only subject to a maximum of Rs. 10,000/- per beneficiary **(Annexure XIII)**.

The subsidy pattern was further, modified during 1995-96. The revised pattern of the subsidy was at the rate of 50% of the cost subject to a maximum of Rs. 15,000 per beneficiary belonging to the SC/ST communities and women farmers. For other category farmers the subsidy was @ 50% of the cost or Rs. 10,000 per beneficiary.

The subsidy support for sprinkler irrigation system in the year 1996-97 was further modified as given below :

a) 90% of the total cost or Rs. 25,000 per ha whichever is less, for small and marginal farmers, SC/ST and women farmers;

b) 70% of the total cost or Rs. 25,000 per ha whichever is less, for other farmers;

c) The above assistance will be available for the land holding size permissible under the relevant State Land Ceiling Laws.

d) In the case of women farmers, the assistance will be admissible only to those whose names occur on the land revenue records as land holders, and will be restricted to her share in case of her being a joint holder.

Some Suggestions :

The subsidy support for sprinkler irrigation system is available under Pulse Development Project, Increased Crop Development Programmes of cotton, wheat and rice.

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

ii) The high cost is due to imposition of excise duties, customs duty, sales tax and surcharges. The Government should waive all the taxes to bring down the high cost in the interest of the agricultural sector and saving water for the community as a whole. The waiver will minimize the capital cost substantially and the farmers will install the system of their own accord without unduly bothering about subsidy.

iii) The State Governments should effectively implement the Central Government subsidy schemes on sprinkler irrigation.

iv) The Government should arrange the visit of farmers to different successful farms in various regions/states to inculcate the spirit of confidence and conviction about the system.

v) To make the system popular, all means of mass media (TV, Radio, News Papers and publicity materials) and communication strategies should be adopted with special emphasis for dissemination of information about successful ventures by various farmers in different crops. Large number of seminars/workshops and training sessions should be organized to make the people aware of the advantages of the system .

vi) To educate the farming community on the overall benefits, large scale demonstration farms are to be organized in each block.

vii) To popularize the scheme in the initial stages, interest free loans through financial institutions, at least for few years should be freely forthcoming to the farming community.

viii) To give impetus for large scale adoption, a State Level Committee may be constituted to extend policy support.

ix) To motivate the farmers to take up sprinkler systems, power supply should be extended to them on priority basis for some years.

9.2.2 Manufacturing/Firms

i) The companies/firms should supply only good quality material of standard specification as specified by Bureau of Indian Standards **(Annexure XIV)**.

ii) The companies should improve upon their after-sale service since many firms are not serious and sometimes prefer to neglect once the payment is settled.

iii) The company should take up the design and estimate only after critically analyzing area, topography, soil, water, and crops to be grown.

iv) The company/firm should train their own staff in various areas of sprinkler system and they should be fully aware of the various implications, problems and remedies. They should also possess basic knowledge on crops and farming to do a better service.

v) The firms should render free advice to the farmers about the operation, duration of operation, how to maintain the system etc., for a successful working of the system. They should give manuals to the farmers giving full information about the important aspects including operation of the system.

vi) Companies should show to their prospective customers their own demonstration units installed in the farmer's field.

vii) The manufacturing companies should have their own R & D cell to provide necessary technical support to the farmers.

9.2.3 Financial Institutions

The financial institutions have been playing a key role in promoting sprinkler irrigation systems by providing financial assistance to all categories of farmers. All Commercial banks, State Land Development banks are providing loan assistance to individual users. Refinance to all loans are provided by NABARD. NABARD has also provided the technical and commercial guidelines to the banks for financing sprinkler systems. The technical parameters include type of crop, water requirement, design aspects and components required and cost thereof and investment spacing. The financial aspects include assessing the incremental income, Internal rate of return (IRR) and Expected rate of return (ERR), Benefit Cost (BC) Ratio, repayment capacity of the borrower and bankability of the scheme or project.

9.2.4 Farmers

i) Farmers continue to entertain the thought that larger the quantity of water applied to any crop greater is the yield despite scientific finding to the contrary. They should develop conviction and confidence after seeing the successful crop performance in sprinkler farms. An attitudinal change is to be brought through extension education.

ii) Once the system is installed, they 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.

iii) Cases are not wanting, where farmers have fully/partially disbanded the system once sufficient quantity of water became available in the wells. This violates the basic concept of the system. Once installed, the irrigation should be done only through the system and then only the full benefits could be realised. There are many cases that the pipes are used only for conveying the water and sprinklers are not used for irrigation.

iv) Further, the farmers are experiencing innumerable problems in obtaining subsidy due to procedural difficulties. It would be better to have one single agency to process the applications and extend the subsidy benefits. This is a capital intensive investment which acts as a deterrent to be adopted by most of the farmers.

9.2.5 Research

Information of uniformity and water distribution pattern in sprinkler irrigation is essential to apply water uniformly in the field.

In sprinkler irrigation, the studies with respect to crop response is essential to establish the feasibility of utilization, crop water requirement and schedule of operation in any agro-climate zone.

To introduce sprinkler irrigation system in canal command areas, the operation schedules of the canal is to be matched with the operation of the system to suit the crop water requirements. In some situations, storages can be created within the canal command area for storing and use of water during canal closure periods and when canal supplies became lean. Economic analysis is essential with respect to utilisation of sprinkler irrigation systems in any agro-climatic zone.

Irrigation scheduling as well irrigation requirements of various kinds of crops during their different phases of growth are not available. Research focus should be on field-based experiments using sprinkler systems as specific to each crop.

Precise information on number of sprinklers, their spacing, overlapping and placement is also required to be developed.

9.3 PERSPECTIVE PLAN FOR DEVELOPMENT

Land and water resources are constant. But it will be possible to increase the gross area even to twice that of the net area provided sufficient water is available to take two crops in a year. Therefore, water is the constraint for the agricultural development and to increase the production. To overcome these problems to some extent, sprinkler irrigation is to be introduced wherever it is suitable.

In water scarce areas , the farmers are convinced that this system is beneficial despite its high cost. The problem is the cost. The Centre and many State Governments are interested in introducing sprinkler irrigation in order to solve the problem of scarce water and to take increased production by bringing large area under irrigation. Still there is a large ground to cover in introducing sprinkler irrigation in all the states and in canal and tank commands apart from wells. The Government should fix a target of 5% and 10% of the irrigated area under sprinkler for the year 2005 and 2015 indicating the crops and the areas/zones in each state and act accordingly. This will solve many problems in the country including unemployment and foreign exchange by exporting food grain and other agriculture commodities. Necessary funds should be provided by the State and Central Government in order to introduce the system in the needed areas and the crops. Since water is the major constraint for agriculture production to feed the growing population, sufficient attention and care should be given for introducing sprinkler irrigation for many crops in the country. But more concentrated efforts are needed to strengthen the extension support and technical man power to create awareness among the farmers. The Research and Development (R&D) support is also very important to provide the feed back on the problems faced by the farmers. There is a vital need to develop a cheaper, more adoptive sprinkler technology for the farmers.

Crops Grown Under Sprinkler Irrigation

I. CEREALS

1. Maize
2. Sorghum
3. Wheat
4. Jowar
5. Bajra
6. Barley

II. FLOWERS

1. Chrysanthemum
2. Carnation
3. Jasmine
4. (All) Ornamental Trees & Shrubs Marygold

III. FODDERS

1. Alfalfa
2. Asparagus
3. (All) Pastures

IV. FIBRES

1. Cotton
2. Sisam

V. OILSEEDS

1. Groundnut
2. Mustard
3. Sunflower
4. Safflower
5. Toria
6. Linseed

IV. PULSES

1. Gram
2. Pigeonpea
3. Lintel
4. Beans

VII. VEGETABLES

1. Onion
2. Potato
3. Raddish
4. Carrot
5. Garlic
6. Cabbage
7. Khol chol
8. Spinach
9. Fenugreek
10. Cukerbeets
11. Sugarbeets
12. Lettuce
13. Sweet Potato

VIII. PLANTATION CROPS

1. Coffee
2. Rubber
3. Tamarind
4. Tapioca
5. Tea
6. Teak

IX. SPICES

1. Cardamom
2. Pepper

Annexure II

Adoption of Sprinkler Irrigation for Crop Production Oriented Centrally Sponsored Schemes (Wheat and coarse grain cereals) During VIII Plan Period.

S. No.	Name of State	Sprinkler sets installed (Nos.)					
		92 - 93	93 - 94	94 - 95	95 - 96	96 - 97	
						Wheat etc.	Rice
1.	Andhra Pradesh	224	79	37	1810	-	500
2.	Arunachal Pradesh	-	-	-	80	-	17
3.	Assam	-	-	-	150	-	150
4.	Bihar	-	-	-	600	-	500
5.	Goa	-	-	-	50	-	25
6.	Gujarat	22	43	52	310	100	-
7.	Haryana	-	-	-	2000	2000	-
8.	Himachal Pradesh	-	-	-	50	100	-
9.	Jammu & Kashmir	-	-	-	100	80	-
10.	Karnataka	35	107	27	185	32	-
11.	Kerala	-	-	-	-	-	150
12.	Madhya Pradesh	36	37	42	5060	1400	50
13.	Maharashtra	106	956	522	3700	2015	-
14.	Manipur	-	-	-	10	-	70
15.	Meghalaya	-	-	-	10	-	35
16.	Mizoram	-	-	-	100	-	70
17.	Nagaland	-	-	-	7	-	385
18.	Orissa	-	-	-	1570	-	-
19.	Pondicherry	-	-	-	-	-	10
20.	Punjab	-	-	-	250	200	-
21.	Rajasthan	-	140	252	2600	2250	-
22.	Sikkim	-	-	-	40	-	40
23.	Tamil Nadu	205	1312	1024	300	-	500
24.	Tripura	-	-	-	10	-	-
25.	Uttar Pradesh	-	-	-	1250	345	-
26.	West Bengal	-	-	-	200	-	385
	Total	628	2674	1956	20442	8522	2887

Annexure III

S. No.	Name of State	Sprinkler sets installed (Nos.)				
		1992-93	1993-94	1994-95	1995-96	1996-97
1.	Andhra Pradesh	340	987	3485	5760	240
2.	Arunachal Pradesh	-	10	-	-	-
3.	Assam	-	-	-	-	-
4.	Bihar	-	-	-	192	240
5.	Gujarat	941	1511	2555	4160	240
6.	Haryana	-	-	343	1000	80
8.	Himachal Pradesh	-	-	-	-	-
9.	Jammu & Kashmir	-	-	-	-	16
10.	Karnataka	1322	950	712	640	400
11.	Kerala	-	-	10	-	-
12.	Madhya Pradesh	99	108	441	2080	1360
12.	Maharashtra	1685	1380	2123	1760	800
13.	Manipur	-	-	-	-	160
14.	Meghalaya	-	-	-	-	-
17.	Orissa	-	50	-	72	800
18.	Punjab	-	-	-	-	-
19.	Rajasthan	693	1270	4105	6800	1280
20.	Sikkim	-	-	-	-	144
21.	Tamil Nadu	1466	756	2238	1760	800
22.	Tripura	-	-	-	-	1200
23.	Uttar Pradesh	-	214	2430	-	2400
24.	West Bengal	-	-	-	976	-
	Total	6546	7236	18442	25200	10160

Table title (printed above the table): **Adoption of Sprinkler Irrigation for Crop Production Oriented Centrally Sponsored Schemes (C . Seeds) During VIII Plan Period.**

Annexure IV

S. No.	Name of State	Sprinkler sets installed (Nos.)				
		1992-93	1993-94	1994-95	1995-96	1996-97
1.	Andhra Pradesh	245	93	269	769	4880
2.	Arunachal Pradesh	-	-	-	-	-
3.	Assam	-	-	-	-	-
4.	Bihar	61	30	21	225	400
5.	Goa	-	-	-	6	1600
6.	Gujarat	57	43	51	100	640
7.	Haryana	652	-	369	400	-
8.	Himachal Pradesh	-	-	2	-	-
9.	Jammu & Kashmir	NR	-	5	23	-
10.	Karnataka	167	145	188	240	800
11.	Kerala	-	-	-	-	-
12.	Madhya Pradesh	11	162	585	2000	4960
13.	Maharashtra	341	241	351	450	3200
14.	Manipur	NR	-	-	-	-
15.	Meghalaya	NR	-	-	-	-
16.	Nagaland	-	-	-	9	-
17.	Orissa	NR	-	-	423	-
18.	Punjab	NR	-	-	-	-
19.	Rajasthan	214	859	2003	1900	4960
20.	Sikkim	-	-	-	-	-
21.	Tamil Nadu	317	153	215	250-	
22.	Tripura	NR	-	-	-	-
23.	Uttar Pradesh	343	595	1153	1000	-
24.	West Bengal	NR	-	-	-	-
25.	A & N Island	-	-	-	-	-
26.	Delhi	-	-	-	-	-
	Total	1757	2374	5212	8295	21440

Table title: **Adoption of Sprinkler Irrigation for Crop Production Oriented Centrally Sponsored Schemes of National Pulses Development Project During VIII Plan Period.**

Annexure V

Adoption of Sprinkler Irrigation for Crop Production Oriented Centrally Sponsored Schemes of Intensive Cotton Development Programme During VIII Plan Period.

S. No.	Name of State	Sprinkler sets installed (Nos.)			
		1992-93	1993-94	1994-95	1995-96
1.	Andhra Pradesh	224	79	37	507
2.	Gujarat	22	43	52	220
3.	Karnataka	35	107	27	85
4.	Madhya Pradesh	36	37	42	60
5.	Maharashtra	106	956	522	700
6.	Rajasthan	-	140	252	600
7.	Tamil Nadu	205	1312	1024	300
	Total All India	628	2674	1956	2472

List of Institutions Engaged in Research on Sprinkler Iiirgation Systems

A. STATE AGRICULTURAL UNIVERSITIES :

i) Department of Agricultural Engineering, Andhra Pradesh Agricultural University, Rajendra Nagar, Hyderabad, Andhra Pradesh.

ii) Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

iii) Department of Agricultural Engineering, Haryana Agricultural University, Hissar, Haryana.

iv) Water Management Project, Navsari Campus, Gujarat Agricultural University, Navasari, Gujarat.

v) Department of Agricultural Engineering, Punjabrao Krishi Vidyapeeth, Krishi Nagar, Akola, Maharashtra.

vi) Department of Agricultural Engineering, Govind Ballabh Pant Agricultural University, Pant Nagar, Udham Singh Nagar, U.P.

vii) Department of Agricultural Engineering, Punjab Agricultural University, Ludhiana, Punjab.

viii) Department of Agricultural Engineering, Rajasthan Agricultural University, Udaipur, Rajasthan.

ix) Department of Agricultural University, Jawaharlal Nehru Krishi Vishvavidalya, Jabalpur, Madhya Pradesh.

x) Department of Agricultural Engineering, Indira Gandhi Krishi Vishvavidalya, Raipur, Madhya Pradesh.

xi) Assam Agricultural University, Jorhat, Assam.

xii) Department of Agricultural Engineering, Mahatma Phule Krishi Vishvavidalya, Rahuri, Ahmednagar, Maharashtra.

xiii) Kerala Agricultural University, Trishur, Kerala.

xiv) Department of Agricultural Engineering, Rajendra Agricultural University, Pusa, Samastipur, Bihar.

B. INDIAN COUNCIL OF AGRICULTURAL RESEARCH INSTITUTES:

i) Water Technology Centre, Indian Agricultural Research Institute, New Delhi.

ii) Water Technology Centre for Eastern Zone, Bhuvneshwar, Orissa.

iii) Directorate of Water Management , ICAR, WALMI Campus, Patna, Bihar.

iv) Central Soil Salinity Research Institute, Karnal, Haryana.

v) Central Institute on Post Harvest Technology (ICAR), PAU Campus, Ludhiana, Punjab.

vi) Central Institute for Agricultural Engineering, Bhopal Madhya Pradesh.

C. OTHER ASSOCIATED INSTITUTES :

i) Water & Land Management Institute, Anand, Gujarat.

ii) Water & Land Management Institute, Aurangabad, Maharashtra.

iii) Water & Land Management Institute, Bhopal, Madhya Pradesh.

iv) Central Designs Organization, Gandhi Nagar, Gujarat.

v) Water Resources Engineering & Management Institute, Samiala, Vadodara, Gujarat.

vi) University of Agricultural Sciences, Bangalore, Karnataka.

vii) Department of Agricultural Engineering, Indian Institute of Technology, Kharagpur, West Bengal.

viii) Water Resources Development Training Centre, University of Roorkee, Roorkee, U.P.

ix) Water Management Division, Centre for Water Resources Development and Management, Calicut, Kerala.

Annexure VII

Research Schemes Sanctioned by the Ministry of Water Resources, Government of India Under the River Valley Projects on the Topics of Drip and Sprinkler Irrigation.

Sl. No.	Institute	Title	Amount (Rs. lakhs)
(a)	**Sanctioned upto 1991-92**		
1.	Punjab Agricultural University, Ludhiana - 141004 Punjab	Performance Studies of Sprinkler, Drip Irrigation and Surface Irrigation Methods.	3.55
2.	Tamil Nadu Agricultural University, Coimbatore-641003 Tamil Nadu	Coparative Studies of Sprinkler & Drip Irrigation Methods with Conventional Surface Methods.	4.15
3.	Narendra Dev University of Agril & Technology, Faizabad-224001 Uttar Pradesh	Comparative Studies of Sprinkler & Drip Irrigation Methods with Conventional Surface Methods for Crop Production under Eastern Uttar Pradesh Conventions.	5.77
4.	College of Technology & Agricultural Engg., Rajasthan Agril. Univer Udaipur-313001 Rajasthan	Performance Evaluation of Sprinkler & 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
6.	WTC, TN Agricultural University, Coimbatore Tamil Nadu	Comparative Evaluation and Economic Appraisal of Different Modes of Application of Drip System.	3.00
7.	WREMI, Samiala Gujarat	Optimisation of Drip Irrigation Layout & Design for Row Crops and Orchards	6.00
		Total (b)	**15.00**

Annexure VII (contd.)

Sl. No.	Insttitute	Title	Amount (Rs. lakhs)
(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-Irrigtion Technology.	6.57
		Total (c)	**14.49**
(d)	**Sanctioned during 1994-95**		
10.	Punjabrao Krishi Vidyapeeth, Akola	Design, Development and Testing of Sub-Surface Drip Irrigation.	4.846
11.	Agricultural Research Station, Thrissur, Kerala	Development of Mulch-cum-Drip and Sub-surface Pad Irrigation System for Vegetables.	5.876
12.	Punjab Agrilcultural University, Ludhieana	Development drip irrigation system for field scale implementation for orchard and field crops.	6.470
13.	Bidhan Chandra Krishi Vishwavidyalaya, Kalyani West Bengal	To study the performance of bamboo Main and Lateral for gravity drip irrigation in hybrid tomato and banana cultivation.	0.736
14.	Agricultural Research Station, Tamil Nadu Agril. University, Bhavanisagar	Effect of Irrigation Schedules & Nitrogen levels on the yield of turmeric through drip method of irrigation.	0.800
15.	Agricultutal Research Station, Tamil Nadu Agril. University, Bhavanisagar.	Studies on the Effect of Irrigation Schedules & Nitrogen Levels on the yield & Quality of Sugarcane through drip method of irrigation.	1.860
		Total (d)	**20.588**
(e)	**Sanctioned during 1995-96**		
16.	Punjab Agriltural University, Ludhiana	Performance Studies of Sprinkler, Drip & surface Irrigation methods.	4.580
		Total (e)	**4.580**
		Total (a)+(b)+(c)+(d)+(e)	**72.718**

A Study of Prpblems Encountered by the Farmers in Sikar District, Rajasthan - A Case Study

A study of sprinkler irrigation systems in Sikar district of Rajasthan was undertaken by G.B. Pant Agricultural University, Pantnagar, to evaluate their performance.

It was observed that sprinkler system was popular among the small land holding farmers, because of higher amount of subsidy, convenience of operation of system and its utility in saving water and in unlevelled land. Farmers were using 7.5 hp. and 10 hp. pumps. It was observed that due to higher suction and delivery heads most of the available head was consumed in lifting the water. Therefore, the farmers were operating their systems at a low pressure. About 60 percent farmers were using the operating pressure less than 1 kg/cm^2. Others were using their systems at an operating pressure upto 2.11 kg/cm^2.

It was observed that due to friction with water containing some amount of sand particles, there was a wear in nozzle orifice. This resulted in variation of radius of coverage from the rated one, some variation was also due to incompatible nozzle sizes used by the farmers. Jet break up index of sprinklers was compared with the calculated jet break up index, from the manufacturer's performance charts. It was found to increase with pressure. There existed a difference between observed and expected jet break up index because of nozzle wear and improper nozzle size used by the farmers.

It was further observed that the farmers were using the lateral spacings which were not within the recommended range. About 35 per cent of the total studied farmers were using the lateral spacing less than 55 per cent of wetted diameter of sprinklers and 65 per cent farmers were using the spacing between 60 per cent to 90 per cent of the wetted diameter of their sprinklers. Due to wider spacing, the uniformity of water application was affected, resulting in improper crop growth.

Uniformity coefficient was determined for some of the sprinkler systems. It was observed that uniformity coefficient was higher, when the operating pressure was around 2.11 kg/cm^2.

A study of problems encountered by the farmers in using sprinkler systems suggested that if the farmers could be trained appropriately to take care of their systems, the minor repairs could be done by the farmers themselves.

Opinion survey of farmers was done regarding the utility of sprinklers. It was observed that the popularity of the sprinkler system was mainly because of :
i) no neccessity of attention during irrigation;
ii) labour saving;
iii) its versatility in unlevelled land and
iv) water saving.

It was observed that the area under a crop was not significantly related to its yield levels. However, it was observed that the yield of the most of the crops was significantly related to irrigation application. For wheat, barley and bajra the relationship was linear, however the yield of groundnut was related to water application by a power form of equation.

A study of benefit cost ratio for one agricultural year indicated that the ratio of benefit to cost lied between 1.75 to 2.14. The average income per hactare of farmers was between Rs. 2778.40 to Rs. 3276.90.

Based on "Study of Field Sprinkler Irrigation in Sikar District of Rajasthan", following conclusions were drawn :

1. Unlike the present practice of improper overlapping of sprinklers, it is desirable that lateral spacing should be kept such as to provide 50 per cent overlap of the wetted diameter and thus a good uniformity of coverage.

2. Genuine spare parts, presently not available conveniently to the farmers, should be made available and recommended for replacement of worn out parts of already installed sprinkler as and when necessary.

3. It is desirable that the sprinkler system shoud be operated at a pressure closer to the manufacturer's specifications, such as to get a good uniformity of coverage, and droplet distribution.

4. To encourage the use of sprinkler systems, the repair and after sale services should be strengthened by the state agencies and the dealers, to make it easily and economically available at the village level.

5. A short term training for farmers, regarding installation, operation and maintenance of sprinkler systems should be arranged by all concerned agencies.

Seminars/Workshops, Training Programmes and Their Recommendations

I. SEMINARS/WORKSHOPS/TRAININGS :

1. Irrigation and Water Management in India - A Modern Perspective.
2. Seminar on Sprinkler and Drip Irrigation, Ministry of Irrigation, New Delhi, 1984.
3. Short term course on Sprinkler and Drip Irrigation, WTC, IARI, New Delhi, 1985.
4. National Seminar on Use of Plastics in Agriculture, NCPA, New Delhi, 1987.
5. National Seminar on Drip and Sprinkler Irrigation Methods, MPAU, Rahuri, 1987.
6. Development and Management of Training Course on Pressurized System of Irrigation, WAPCOS, 1987.
7. Short Training programme on Sprinkler and Drip System, Anna University, Madras, 1989.
8. National Workshop on Drip & Sprinkler Irrigation, Pune, 1990.
9. Training Course on Drip & Sprinkler Irrigation Systems, Design and Layout, CWRDM, Kozhikode, Kerala 1991 & 1992.
10. Workshop on Sprinkler and Drip Irrigation System, Jalgaon, 1993.
11. All India Seminar on Sprinkler and Drip Irrigation, Hyderabad, 1993.
12. All India Seminar on Sprinkler and Drip Irrigation, Chandigarh, 1993.
13. All India Seminar on Sprinkler and Drip Irrigation, Bhubaneshwar, 1995.
14. All India Seminar on Sprinkler and Drip Irrigation, Bangalore, 1996.

II. GENERAL RECOMMENDATIONS OF VARIOUS SEMINARS/ SYMPOSIA/WORKSHOPS

1. The industry should establish research and development base for ensuring better performance and continued improvement of equipment. After sales services are very important and must be made available at easily accessible locations.

2. 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.

3. Training of farmers and field workers in the proper use of sprinkler and drip Irrigation systems should be orgnaised on a regular basis by a competent agency, taking into consideration the specific requirements of trainees and 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.

4. Large scale demonstrations on sprinkler and drip Irrigation should be orgnaised by the Industry and the concerned agencies on different crops under varying conditions to promote the systems and ensure their viability and stability.

5. 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 shall be responsible for identifying the agency or the individual for certifying the adherence or otherwise to the prescribed standards and the suitability of the material for the purpose offered.

6. Before recommending to the farmers the use of fertilizers 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 concerned official agency.

7. 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 irrigation.

8. 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.

9. 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 industries 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 the farmers and ensure the stability of the sprinkler and drip irrigation systems and other latest technologies for effective water use.

Annexure X

Outline of Recommendations Made on Sprinkler Usage in Different Crops in Gujarat								
Sl. No.	Crop	Location	Recomm-ended Treatment (IW/CPE Ratio)	Water Saving (%)	Yield Increase (%)	Addl. Return ('000 Rs/ha)	Addl. Area (ha)	Addl. Net Profit for same qty of water used as in surface ('000 Rs)
1	2	3	4	5	6	7	8	9
1.	Cauliflower	Navsari	0.90	35	12	5.6	0.52	32.6
2.	S'groundnut	S.K. Nagar	0.75	23	14	1.6	0.30	7.7
3.	Fenugreek	Jagudan	0.75	29	35	1.4	0.41	2.4
4.	Potato	Deesa	0.90	46	4	5.1	0.86	22.9
5.	Gram	S.K. Nagar	0.75	11	31	2.7	0.13	4.1
6.	Wheat	Vijapur	1.00	31	18	-	0.45	10.2
7.	Maize	Godhra	0.75	41	36	1.3	0.70	3.8
8.	Lucerne	Anand	0.90	16	27	0.8	0.18	1.6
9.	S'groundnut	Anand	0.75	21	42	2.9	0.26	5.4
10.	Wheat	Kandha	0.75	32	36	3.8	0.47	10.4
11.	Gram	Vyara	S+B	69	57	1.8	2.20	7.1
12.	Cowpea (Summer)	Navsari	1.00	19	3	1.2	0.23	4.0
13.	S'groundnut	Vyara	0.45	49	-	-	0.94	4.0
14.	Sugarcane	Navsari	0.45	42	12	3.3	0.73	25.3
15.	Lucerne	Navsari	0.70	35	4	-	0.54	4.8
16.	Cabbage	Navsari	0.60	40	3	7.6	0.67	32.6
17.	Wheat	Navsari	0.60	62	13	2.3	1.50	34.0
18.	S'groundnut	Navsari	0.60	24	30	2.7	0.32	15.0

Source : Plasticulture Development Centre Gujrat Agricultural University, Navasari, Gujrat.

Some Examples of Economic Analysis of use of Sprinkler System

TABLE 1 : HDPE SPRINKLER SYSTEM IN TAWA COMMAND AREA, M.P.

INTRODUCTION

Command Area Development Authority for Tawa Command River Project near Hoshangabad, M.P. were faced with a typical problem. In many areas the canal was passing through an undercut. In many areas the water level in the canal was lower than the ground level and natural gravity aided irrigation was not possible.

CONCEPT

In order to irrigate this land and conserve precious water, the Commissioner of the Project and all officials decided to incorporate sprinkler irrigation system. 40 ha. of land adjoining the canal in village Gurmukhi, Taluka Babal, Distt. Hoshangabad, M.P.

FEATURES

The sprinkler irrigation system became operational in December, 1986 in village Gurmukhi. It was possible to irrigate the entire 40 ha. plot using the system ahead of the schedule. Following special advantages were observed by the HDPE sprinkler irrigation system when compared with aluminum sprinkler system which was also put to use in adjoining 40 ha. plot.

1. Early completion of project with satisfactory commissioning.
2. Complete irrigation with 64 nozzles. No area left out at corners.
3. Pipes conform to undulating territory, hence no land leveling or support to the pipes were required.
4. Saving in power to the time of 30%. The HDPE sprinkler system operates on 20 HP pump whereas aluminum pipe sprinkler system operates at 30 HP pump.

5. Comparative Data :

		Aluminum System	HDPE System
a)	Area	41 ha.	44 ha.
b)	Electricity cost per ha	Rs. 20.00	Rs. 12.95
c)	No. of irrigations	2 1/2 Cycles	4 Cycles
d)	Application Rate	4 Hrs.- 3.4 cm	4 Hrs.- 4.8 cm
e)	Irrigation Interval	20 days	15 days
f)	Yield/ha.	1.0	1.5
g)	No. of Nozzles	32 nos.	64 nos.
h)	Members of Society	16	17

TABLE 2 : INSTALLATION OF SPRINKLER SYSTEM IN FARMER'S FIELDS-CASE STUDY FOR HDPE SPRINKLER SYSTEM

(1) DESCRIPTION OF SPRINKLER SYSTEM :

DATE OF PURCHASE	:	AUGUST 1984 AREA: 2ha.
LENGTH OF UNDER GROUND PIPE	:	NIL
LENGTH OF QUICK COUPLED PIPE	:	180 MTRS.
NO.OF NOZZLES	:	8
PUMP	:	5 HP
ADDITION HP REQUIRED.(If any)	:	NIL

CROPPING PATTERN

Summer Season

Sl. NO.	CROP	WITHOUT SPRINKLER SYSTEM		WITH SPRINKLER SYSTEM	
		AREA SOWN (ha)	YIELD kg/ha	AREA SOWN (ha)	YIELD kg/ha..
1.	GROUNDNUT	0.6	1500	0.6	2750
2.	PULSES	0.4	1500	0.4	1500
3.	MAIZE	1.0		1.0	

***Kharif* Season**

Sl. NO.	CROP	AREA SOWN (ha)	YIELD kg/ha	AREA SOWN (ha)	YIELD kg/ha..
1.	GROUNDNUT	0.8	1500	0.8	2750
2.	JOWAR	1.2	4500	1.2	4500

Average Increase in Production : For Groundnut 1750 kgs
Average Increase in Yield/ha : 1250 Kg/ha
Approximate Increase in Area Sown : NOT APPLICABLE
Salient Points : A. Ample Water is Available in Summer
B. Maize is Not Irrigated With Sprinklers.

NAME : MR. DINESH RATHI, FARM MANAGER
ADDRESS : BALAPUR ROAD, AKOLA.

(2) DESCRIPTION OF SPRINKLER SYSTEM :

DATE OF PURCHASE : 1984-85
LENGTH OF QUICK COUPLED PIPE : 330 mtrs.
LENGTH OF UNDER GROUND PIPE : NIL
NO. OF NOZZLES : 10
HP OF PUMP : 5
ADDITIONAL HP REQD. (If any) : NIL

CROPPING PATTERN

***Rabi* Season**

Sl. NO.	CROP	WITHOUT SPRINKLER SYSTEM		WITH SPRINKLER SYSTEM	
		AREA SOWN (ha)	YIELD kg/ha	AREA SOWN (ha)	YIELD kg/ha..
1.	GROUNDNUT	0.5	1800	1.6	2000
***Kharif* Season**					
1.	COTTON	1.6	1000	1.6	1500
Summer Season					
1.	VEGETABLES	—	—	0.4	15000

AVERAGE INCREASE IN PRODUCTION : 2295 kg OF GROUNDNUT
800 kg OF COTTON.
Rs.5000-6000 OF VEGETABLES.

AVERAGE INCREAESE IN YIELD/ha : 188 kg/ha from GROUNDNUT
500 kg/ha for COTTON.

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APPROXIMATE INCREASE IN AREA SOWN: 1.2 ha IN *RABI* AND 0.4 ha IN SUMMER

NAME : MR. G.M. GUPTA

ADDRESS : AKOLI JAHANGIR, TAL. U.K : AKOI
DISTT : AKOLA

(3) DESCRIPTION OF SPRINKLER SYSTEM:

DATE OF PURCHASE : AUGUST, 1985
LENGTH OF UNDER GROUND PIPE : NIL
LENGTH OF QUICK COUPLED PIPE : 186 MTRS.
NO. OF NOZZLES : 6
HP OF PUMP : 5
ADDITIONAL HP REQD.(If ANY) : NIL

CROPPING PATTERN

Summer Season

Sl. NO.	CROP	WITHOUT SPRINKLER SYSTEM AREA SOWN (ha)	YIELD kg/ha	WITH SPRINKLER SYSTEM AREA SOWN (ha)	YIELD kg/ha..
1.	GROUNDNUT	1.2	1000	2.4	2500
2.	VEGETABLES	0.4	12500	0.8	12500
			15000		15000

AVERAGE INCREASE IN PRODUCTION : 4800 kg FOR GROUNDNUT
AVERAGE INCREAESE IN YIELD/ha : 1500 kg FOR GROUNDNUT
APPROXIMATE INCREASE IN AREA SOWN : 1.6ha

TABLE 3

A R & D STUDY ON ECONOMIC FEASIBILITY OF HDPE SPRINKLER SYSTEM

Area of Holding : 2 ha.

1. Income prior to Installation of Sprinkler System

SEASON	CROP	AREA SOWN ha.	YIELD kg/ha.	TOTAL YIELD kg.	PRICE Rs./kg.	TOTAL AMOUNT Rs.
KHARIF	Cotton	0.8	810	648	5.5	3564
	Jowar	0.8	2500	2000	1.5	3000
	Mung	0.4	510	51	4.5	918
RABI	Wheat	0.8	2500	2000	2.5	5000
	Vegetables	0.4	LUMPSUM			1500
SUMMER	Groundnut	0.8	1820	1456	7.0	10192
	TOTAL INCOME				=	24174
LESS: COST OF CULTIVATION @ Rs. 2500/HECTARE					=	10000
NET INCOME					=	14174

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2. Income after installation of sprinkler system

SEASON	CROP	AREA SOWN ha.	YIELD kg/ ha.	TOTAL YIELD kg.	PRICE Rs./kg.	TOTAL Amount Rs.
KHARIF	Cotton	0.8	891	712.8	5.5	3564
	Jowar	0.8	2750	2200	1.5	3300
	Mung	0.4	861	224.4	4.5	1009.8
RABI	Wheat	0.8	2750	2200	2.5	5500
	Vegetables	0.4				1650
SUMMER	Groundnut	1.2	2002	2402	7.0	16816.8
	Vegetables	0.8				3300
TOTAL INCOME						35497
LESS: COST OF CULTIVATION @ Rs. 2500/ha.						13000
NET INCOME						22497

3. Incremental Income — Rs. 8323
4. Capital cost of sprinkler system — Rs. 10000
5. Incremental cost of sprinkler system
   Loan instalment(@ 10%, 7 yrs. Payback) — Rs. 2050
   Maintenance @ 5% — Rs. 500

   Rs. 2550

6. Cost benefit ratio — 1:3.26
7. Benefit to farmer due to Sprinkler System Rs. 2886 per hectare.

NOTES:

1. Yield data obtained from results of fertilizer and varietical trials on cultivator's fields carried out by Maharashtra Government during 1978-85 and published in Districtwise General Statistical Information of Agricultural Department 1986-1987.

2. Prices of various commodities as prevalent in Vidharbha/Marathwada regions of Maharashtra.

3. Assumed only 10% increase in yield of the crops due to sprinkler system. Studies at four Agricultural Universities of Maharashtra have indicated a trend of 20 to 25% increase in yield and 30 to 35% savings in water due to sprinkler systems.

B : ECONOMIC FEASIBILITY OF SPRINKLER SYSTEM

AREA OF HOLDING : 2 ha.

1. Income prior to installation of sprinkler system

SEASON	CROP	AREA SOWN HECTARES	YIELD kg/ ha	TOTAL YIELD kg.	PRICE Rs./kg.	TOTAL AMOUNT Rs.
KHARIF	Cotton	0.8	810	648	5.5	3564
	Jowar	0.8	2500	2000	1.5	3000
	Mung	0.4	510	204	4.5	918
RABI	Wheat	0.8	2500	2000	2.5	5000
	Vegetables	0.4	L.S.			1500
SUMMER	Groundnut	0.8	1820	1456	7.0	10192

TOTAL INCOME	24174
LESS: COST CULTIVATION OF @ Rs. 2500/ha.	10000
NET INCOME	14174

2. Income after Installation of Sprinkler System

KHARIF	Cotton	0.8	891	712.8	5.5	3920.4
	Jowar	0.8	2750	2200	1.5	3300
	Mung	0.4	561	224.4	4.5	1009.8
RABI	Wheat	0.8	2750	2200	2.5	5500
	Vegetables	0.4				1650
SUMMER	Groundnut	1.2	2002	2402	7.0	16816.8
	Vegetables	0.8				3300

TOTAL INCOME	35497
LESS: COST OF CULTIVATION @ Rs. 2500/ha.	14300
NET INCOME	21197
3. Incremental income	Rs. 7023
4. Capital cost of sprinkler system	Rs. 12000
5. Incremental cost of sprinkler system	
Loan instalment(@ 10%, 7 yrs. Payback)	Rs. 2460
Maintenance @ 5%	Rs. 600
	Rs. 3060
6. Cost benefit ratio	1:2.29

7. Net benefit to farmer due to Sprinkler System Rs. 1981 per hectare.

NOTES:

1. Yield data obtained from results of Fertilizer and varietical Trials on cultivator's fields carreid out by Maharashtra Government during 1978-85 and published in Districtwise General Statistical Information of Agricultural Department 1986-1987.

2. Prices of various commodities as prevalent in Vidarbha/Marathwada regions of Maharashtra.

3. Assumed only 10% increase in yield of the crops due to sprinkler system. Studies at four Agricultural Universities of Maharashtra have indicatd a trend of 20 to 25% increase in yield and 30 to 35% savings in water due to sprinkler systems.

TABLE 4

COMPARATIVE POWER REQUIREMENT FOR HDPE AND ALUMINIUM PIPE IRRIGATION SYSTEM.

FARM DATA	FARM A	FARM B	
1. AREA	2	4	ha.
2. LENGTH	144	200	MTRS
3. BREADTH	144	200	MTRS
4. PUMPING HOURS AVAILABLE	12	12	HRS.
5. RATE OF WATER REMOVAL	0.5	0.5	CM PER DAY
6. DEPTH OF IRRIGATION	5	5	CMS
7. SUCTION HEAD	5	5	MTRS

WATER REQUIREMENT : $Q = \frac{A \times D}{1 \times H \times EFF.}$

Q - Discharge, m^3 per hour
A - Area of Farm, m^2
D - Depth of Irrigation, m
I - Irrigation Interval, Days
H - Pumping Hours Available per day
EFF - Irrigation Efficiency = 40% for Flow Irrigation

FRICTION LOSS :

$$FR = \frac{[\quad Q \quad]}{[1002 \times C \times (DIA)^{2.63}]}$$ 1/0.54 Lenght of pipe line.

FR - Friction loss mtr. per mtr.
DIA - Inside diameter of pipe mtrs.

1. FOR FLOW IRRIGATION

	Farm A	Farm B
Water Required, lps	5.78	1.57
Dia of Pipe, mm	75.00	75.00
Total Pump Head, mtrs	12.52	29.54
HP Required	3.00	7.50

2. FOR SPRINKLER IRRIGATION

	With HDPE Sprinkler System		With Aluminum System	
	Farm 2 ha.	Farm 4 ha.	Farm 2 ha.	Farm 4 ha.
1. Max. Irrigation Interval, Days	10	10	10	10
2. Nozzle Selection	(5.6x3.2)mm	(5.6x3.2)mm	(5.6x3.2)mm	(5.6x3.2)mm
2.1 Operation Head Mtrs.	20	20	40	40
2.2 Discharge Mtr. J/Hr.	2.17	2.17	3.08	3.08
2.3 Spacing Mtr. * Mtr.	******* 12 *	12 *****	****** 18 *	18 ****
2.4 Application Rate	1.51	1.51	95	.95
3. No. of Hours/Shift	3.88	3.88	5.53	5.53
4. No. of Shifts per Day	3	3	2	2
4.1 Total No. of Shifts	30	30	20	20
5. Area Covered/Shift Sqm.	666.66	1333.3	1000	2000
6. No. of Nozzles Required	5	9	3	6
7. Total Discharge c.r.m./hr.	10.89	19.61	9.24453	18.48
8. Pressure Calculations				
8.1 Length of Main Line(75mm DIA)	216	300	216	300
8.2 Length of Lateral (75 mm DIA)	72	100	72	100
8.3 Head Loss in Main Line, m	1.96	8.09	1.64	8.25
8.4 Head Loss in Lateral, m	.32	1.34	.27	1.37
8.5 Riser Pipe Height, m	1	1	1	1
8.6 Nozzle Operating Head, m	20	20	40	40
8.7 Total Delivery Head, m	23.92	30.44	42.92	50.62
8.8 Suction Head	6	6	6	6
8.9 Total pump Operating Head,m	29.29	36.44	48.92	56.62
9. Horse Power Required (Actual),	HP 5 *	7.5	7.5	10
10. percentage Increase Over Flow	66.7	0	150	33.3

Can Remain 3 HP if well is at Centre of Field.

Manufacturers of Drip and Sprinkler Irrigation Systems

1. Agritools, 1-2-33/5 Gaganmahal Road, Domalguda, Hyderabad - 500 029, Andhra Pradesh.
2. Ago-Engineering Co. 6-6-37-4 Kavadiguda, Adjacent lane to Petrol pump, Secunderabad - 500 003, Andhra Pradesh.
3. Agroplast, 14 Belladapet, Tiptur - 572 201, Karnataka.
4. Ajanta Plastic Industries, 31/A Cooperative Industrial Estate, MIDC, Ahmednagar - 431 005, Maharashtra.
5. Ajay Industrial Corporation, Head Office, 4561 Deputy Ganj, Sadar Bazar, Delhi - 110 006.
6. Alpha Plastic Industries, L-2326/3&4, GIDC, 3rd Phase, Vapi - 396 191, Gujarat.
7. Anil Kumar & Co., Opp. Pathic Ashram, 1st Floor, Bhavnagar -364 001, Gujarat.
8. Ashok India Aghro Products, Post Box No. 66, C-5/2 New MIDC Area, Ajanta Road, Jalgaon - 425 003, Maharashtra.
9. Batliboi & Co. Ltd., 3-A Surya Towers, Sardar Patel Road, Secunderabad - 500 003, Andhra Pradesh.
10. Bhoruka Aluminium Ltd., 1 K.R.S Road, Metagalli, Mysore - 570 016, Karnataka.
11. Coimbatore Irrigation Equipment and Consultancy Services, Kungar-upalayam, P.O. Kangayam TK, Udhiur - 638 705, Tamil Nadu.
12. Coromandel Indag Products (I) Ltd., 62 Spurtank Road, Chetput, Chennai - 600 031, Tamil Nadu.
13. Desert Gold India Irrigation Limited, 157 Arey Road, Goregaon (West), Mumbai - 400 062.
14. Drip India, Lasalgaon, Tal. Niphad, Nasik, Maharashtra.

15. ELGI Equipment Ltd., India House, Trichy Road, Coimbatore - 641 018, Tamil Nadu.

16. EPC Irrigation Ltd., B-20 MIDC, Ambad, Nasik - 422 010, Maharashtra.

17. Flow Tech Power, 137 London Mission School Street, Papanaickenpalayam, Coimbatore - 641 047, Tamil Nadu.

18. Greenthumb Engineers Pvt. Ltd., 103 Pavanbhumi, Somalwada, Wardha Road, Nagpur - 440 025, Maharashtra.

19. Harvel Irrigation (P) Ltd., 301-304 Meghdoot, 94 Nehru Place, New Delhi - 110 019.

20. Irrigation Engineering Company, 5-5-44/45 Raniganj, Hill Street, Secunderabad - 500 003, Andhra Pradesh.

21. Jain Irrigation Systems Ltd., Jain Industrial Complex, Jain Pipe Nagar, P.O. Box No. 20, Jalgaon - 425 001, Maharashtra.

22. Jivan Irrigation Equipment, 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 - 390 016, Gujarat.

24. Kalpataru Irrigation Systems Ltd., 917/190A Sivajinagar, P.O. Road, Pune - 411 004, Maharashtra.

25. Kaveri Drip Irrigation Systems, Plot No. 23/A, Phase III, I.D.A., Jeedimetla, Hyderabad, Andhra Pradesh.

26. Kisan Irrigation Equipment, 1696 Vijayshree Buildings, Trichy Road, Ramanathapuram, Coimbatore-641045, Tamil Nadu.

27. Maya Agencies, 2078 Ushama, 10th Lane, Rajarampuri, Kolhapur, Maharashtra.

28. Montaj Irrigation Systems (P) Ltd., B-4 Ashok Bhavan, 93 Nehru Place, New Delhi - 110 019.

29. Naan-BILT Irrigation Company, 124 Janpath, Thapar House, New Delhi - 110 001.

30. National Organic Chemicals Industries Ltd., Mafatlal Center, Nariman Point, Mumbai - 400 021, Maharashtra.

31. Neo Sud Plantation Pvt. Ltd., Baldota Bhavan, 6th Floor, 117 Maharshi KarveMarg, Churchgate, Mumbai - 400 020, Maharashtra.

32. New Bharat Minerals and Chem., 10 B Haresh Chambers, 313/319 Samuel Street, Mumbai - 400 030, Maharashtra.

33. Parimal Irrigation Engineering, Arvind, 1224 Sadasiv Peth, Near Shivaji Mandi, Pune - 411 030, Maharashtra.

34. Pasumai Irigations Ltd., 29 Police Commissioner's Office Road, Egmore, Chennai - 600 008, Tamil Nadu.

35. Plastro Irrigation Systems, (India) Limited, (A Finolex joint venture), Block D-1, Plot No. 10, MIDC, Chinchwad, Pune - 411 019, Maharashtra.

36. Polyene General Industries Pvt. Ltd., P.B. No. 3208, A-11& A-1 Industrial Estate, Guindy, Chennai-600 032, Tamil Nadu.

37. Polytube Plastics, 175 Shri Samrath Industrial Estate, Pimpalgaon Baswant - 422 209, Nasik, Maharashtra.

38. Premier Irrigation Equipment Ltd., 17/1-C Alipore Road, Calcutta - 700027, West Bengal.

39. Raindrop Equipment (India) Ltd., A-7 MIDC Area, Amravati-444 605, Maharashtra.

40. Santharaj & Sons, 122 Nanjappa Block, Govipuram Post, Bangalore - 560 019, Karnataka.

41. Sathis Agricultural Enterprises, 12-3-8 Main Road, Patti-Veeranpatti - 624211, Anna District, Tamil Nadu.

42. Shivaji Engineering & M Co., 7-A Murarji Peth, Sholapur - 413001, Maharashtra.

43. Southern Agro-Industries, 161 Greams Road, Post Box 7412, Chennai - 600 006.

44. Spento Plastics, Zamavaz, HK Marg, Dahanu Road, Thane - 401 602, Maharashtra.

45. Sprinkler and Drip Irrigation Equipment, Fakhri Manzil, Near Pawar Bun galow, Amrai, Baramati - 413 102, Pune, Maharashtra.

46. Sujay Irrigation System, 497 1st 'G' Cross, 18th Main, 3rd Stage, 4th Block, Basavareshvaranagar, Bangalore-560 079 Karnataka.

47. Telecom Wires & Cables, MS Ramaiah Industrial Estate, Gokula, Bangalore - 560 054, Karnataka.

48. Voltas Limited, 19 JN Heredis Marg, Ballad Estate, Mumbai - 400 038, Maharashtra.

49. Watman Irrigation Systems Pvt. Ltd., Kinkhede Layout, Opp. Hislop Col lege, Civil Lines, Nagpur - 440 001, Maharashtra.

A. Sprinkler irrigation

Pattern of assistance followed for sprinkler irrigation systems under different schemes.

S. No.	Plan scheme	Crops covered	Pattern of assistance			
			As originally approved for the Eighth Five Year Plan 1993-94	As revised for 1994-95	As further revised for 1995-96	As further revised for 1996-97
1.	2.	3.	4.	5.	6.	7.
1. 2. 3.	National Pulse Development Programme (NPDP) Oilseeds Development programme (OPP) Intensive Cotton Development programme (ICDP)	Pulses Oilseed crops Cotton	50% of the cost for small and marginal farmers,subject to a maximum of Rs. 10,000 per beneficiary	75% of the cost for SC&S T farmers, 50% of the cost for small and marginal farmers and 25% of the cost for other categories of farmers, subject to a maximum of Rs.10,000 Per beneficiary	75% of the cost of the system per ha or Rs.15,000 per ha. whichever is less for SC/ST and women farmers and 50 % of the cost system per ha or Rs. of the 10,000 whichever is less for farmers of other categories and available for land holding size subject to the State land ceiling laws.	90% of the cost of the system per ha. or Rs. 25000/ha whichever is less for SC/ST, small/ marginal & Women farmers, 70% for other categories of farmers. The subsidy is available for land holding size subject to state land ceiling laws.

contd/2..

Annexure XIII (Contd.)

S No.	Plan scheme	Crops covered	Pattern of assistance			
			As originally approved for the Eight Five Year Plan 1993-94	As revised for for 1994-95	A further revised for 1995-96	As further revised for 1996-97
1.	2.	3.	4.	5.	6.	
4.	Integrated Cereal Development Programme (ICDP)	Cereals and other crops	—No Scheme—	—No Scheme—	75% of the cost of the system per ha or Rs.15,000 per ha whichever is less for SC/ST and women farmers,and 50 % of the cost of the system per ha or Rs. 10,000 whichever is less for farmers of other categories and available for land holding size subject to the State land ceiling laws.	90% of the cost of the system per ha. or Rs. 25000/ha whichever is less for SC/ST, small/ marginal & Women farmers, 70% for other categories of farmers. The subsidy is available for land holding size subject to state land ceiling laws.

BIS Standards for Sprinkler Irrigation Systems Components

BIS CODE	SUBJECT
IS 12232 (Part 1): 1987	Rotating sprinkler design and operational requirement
IS 12232 (Part 2): 1994	Rotating sprinkler test method for uniformity of distribution
IS 14151 (Part 1): 1994	Polyethylene pipes for sprinkler irrigation system - Pipes
IS 14151 (Part 2): 1994	Polyethylene pipes for sprinkler irrigation system - Couplers
IS 14178 : 1994	Pressurised irrigation equipment - Terminology

National Seminar on Sprinkler Irrigation in India
December 8, 1995
Inaugural Address by the Hon'ble Minister for Water Resources and Parliamentary Affairs

Shri Vidyacharan Shukla

I am very happy to be present here to inaugurate the Seminar on Sprinkler Irrigation in India organised by Indian National Committee on Irrigation and Drainage (INCID).

Water is one of the most crucial elements in the developmental planning. As the country prepares itself to enter the 21st Century, efforts to develop, conserve, utilise and manage this important resource have to be guided by the National perspective.

Water is commonly taken for granted as nature's abundant gift to mankind. In reality, supply of water is by no means unlimited. The lack of water rather than land, may become the principal constraint in efforts to increase the agricultural production for meeting the requirements of our growing population.

Increasing population is leading to increasing demand for water for irrigation, drinking and industries. There is also an alarming trend of supply of good-quality water being contaminated through pollution originating from domestic wastes, industry, agri-chemicals and mis-managed land uses.

While the demand for water is increasing, the costs of development of new sources of water are much higher than the sources already tapped due to various factors including environmental costs.

Some of you may be aware of the recent study "The Food Crisis in South Asia - The Case of India" done by the World Bank about impending food crisis in India. According to the study, water shortage is threatening to become India's greatest environmental crisis.

In view of the vital importance of water for human and animal life and considering its increasing scarcity, the planning and management of this resource has become a matter of utmost urgency.
It has been recognised that among the basic factors of agricultural productivity, adequate and timely provision of water is crucial one. The development of

irrigation has been given top priority in the Indian economic as agriculture contributes to about 50 per cent of the Gross National Product.

According to an estimate, the investment in irrigation rose from about Rs. 1,000/- per hectare during the First Five Year Plan to about Rs 45,000/- per hectare during the Seventh Five Year Plan. In view of this, it is necessary to use water for agriculture as economically as possible. The water saved thus can bring more area under irrigation.

I think time has come for initiating a national dialogue on the development of appropriate strategies in Irrigation for increased agricultural production. Our population may touch about 1,000 million in A.D. 2,000. The demand of foodgrains may go upto about 235 million tonnes. For sometime our production of foodgrains has reached a pleateau of around 180 million tonnes. The production of foodgrains can be increased by bringing more area under irrigation and making more efficient management of water we have at our disposal.

Many States have already harnessed the utilisable surface water resources and about 60 to 70 percent of their groundwater potential. As you are aware, most of the surface irrigation is by gravity method, a lot of the water is wasted in this system. More water is given to the plants than it really needed by them. This is because in the gravity method, it is not possible to regulate water to reach the roots of the plants. Obviously, in order to save the water we need techniques by which water and fertilizer can be placed directly near the root zones of the plants. For some crops we may need techniques which would not flood field but provide just sufficient water needed by the plants.

This is where the importance of the advanced methods of irrigation like Sprinkler and Drip is realised. These methods would result in large scale saving of water needed for irrigation. I am told that overall irrigation efficiency in surface irrigation is only 30 to 50 per cent which is very low. In sprinkler method it is 60 to 75 per cent and in drip method it is as high as 80 to 90 per cent.

There is vast potential for application of Sprinkler method due to the efficiency of its application and its adaptability to hilly terrains. There is no fear of attack of frost in this system. Moreover, it is possible to apply fertilizers dissolved in water.

The Sprinkler method has been in use in many parts of the World for almost 75 years. In our country, however, most of the farmers are not conversant with this technique. Only about 6.00 lakh hectares which is about 1 per cent of the total irrigated area is under sprinkler irrigation. Only 70,000 hectares area is under Drip Irrigation which is about 0.1 per cent of irrigated area in the country. Out of this, an area of 33,000 hectares in Maharashtra alone and 23,000 hectares in Andhra Pradesh and Karnataka. You may imagine how little area is covered by the Drip Irrigation in rest of the Country.

While Sprinkler Irrigation is useful for root type crops, drip irrigation is needed for horticultural crops, flowers and vegetables. Engineers and agriculture experts have to decide the sustainability of these systems for different crops. These methods lead not only to saving of water but confer other benefits also. Yields are definitely improved. Growth of weeds is controlled. There are no problems of salinity and waterlogging because only small areas around the plants are wetted. Drip irrigation can be effective in poor soil and steep terrains.

There is an increasing realisation that use of these methods can result in saving of enormous water and lead to more efficient irrigation.

There are certain impediments in popularising these methods. The initial cost of sprinkler and drip systems is very high. There is not much awareness among the farmers about the need to save water because of inadequate extension facilities. The manufacturing capacity is poor. There are about a dozen manufacturers of sprinkler system and only about 50 manufacturers of drip system.

These can be overcome without much difficulty. Research is needed to reduce the cost of the drip system. The cost can be reduced if use of imported materials of plastics is substituted by indigenous material. Out extension services must be geared up to convey the need for conservation of water and to convince the farmers of the benefits of these methods. The traditional system of irrigation has been in vogue for centuries. But our farmers are very receptive to new ideas if they are convinced of their benefits. Social scientists can play an important role in this.

The Ministry of Agriculture provides subsidy to encourage the use of these methods. We have to ensure that it is properly utilised. There is a need for the industry also to take more interest in manufacturering of these systems.

Although this seminar is about Sprinkler irrigation only yet I think we have to consider both the systems because different crops need either of the systems. I hope you will consider this.

I am sure the Seminar will discuss in depth how water can be conserved by advanced techniques of irrigation and make practical recommendations.

I hereby inaugurate the Seminar.

National Seminar on Sprinkler Irrigation in India on December 8, 1993
Address by the Hon'ble Minister of State for Water Resources

Shri P.V. Rangayya Naidu

I am very happy that the Indian National Committee on Irrigation and Drainage (INCID) is organising this "National Seminar on Sprinkler Irrigation in India". I am glad to know that participants from various organisations, Government as well as Non-Government, round the country including those from leading manufacturers of sprinkler equipments, have been invited to deliberate on this vital topic.

Water is a prime natural resource, a basic human need. Therefore, it is imperative to take stock of the situation every now and then regarding its availability and adoption of proper strategies to meet its evergrowing demand.

Water occupies 3/4th of the surface of the globe and thus it would appear rather odd to call it "scarce". Here it is important to mention that it is the availability of utilisable water for actual use that is scarce and not the total water on earth.

Even the limited supply that ia available is unevenly distributed. The demand of water for various uses such as, irrigation, drinking water supply, industries, power generation, fisheries, navigation or recreation is ever increasing because of the ceaseless rise in human population. To meet with the demands of water, activated by not only increases in population, but also by increases in standard of living as well as increases in varieties of its use, it has become inevitable to search for new techniques, technologies and innovations for conservation of available waters. This would entail, storing, diverting and managing the water resources most judiciously and economically.

Man has always endeavoured to face the challenges, but an ever increasing alertness on all fronts is called for in respect of water as the population is likely to touch 1000 million mark by turn of century and per capita availability will continue to dwindle. With our population projection, our Country will be under water stress by 2050 i.e., the available fresh water resources will be in the range of 1000-1700 cubic metre/capita/year.

In view of the above critical scenario, the Government has always been alerting the intelligensia of the Country not to take water availability for granted. As early as, September, 1987 the Government of India, in its National Water Policy has emphasized that the efficiency of utilisation in all the diverse uses of water should be improved and awareness of water as a scarce resource should be fostered. Conservation consciousness should be promoted through education, training, regulation, incentives, etc. in all sectors of water use.

The use of sprinkler for irrigation is a welcome sign and certainly it is most effective water saving device. I am told that the water saving by sprinkler irrigation is to the extent of 56% on certain crops. In addition to this, there are benefits like (a) water conservation (b) soil conservation (c) higher yields (d) better ways of fertilizer application, etc. etc.

There are however, certain, inherent limitations in use of sprinkler irrigation method like (i) High initial cost (ii) Wind effect reducing uniform sprinkling (iii) evaporation loss (iv) suitability for mainly close growing crops etc. Thus a suitable mix of surface/sprinkler irrigation methods will have to be devised. Government of India is already providing subsidy to encourage adoption of these techniques.

I am sure that the Seminar will cover all the aspects during its deliberations.

Further I congratulate Dr R.K.Sivanappan for preparing this document namely "Sprinkler Irrigation in India". I also congratulate INCID for organising this Seminar and inviting all the concerned organisations for pooling their experience in finalising the report.

I wish the Seminar all success.

Participants in the National Semenar on Sprinkler Irrigation Held at New Delhi on 07.12.1995

1. Shri P.V. Rangayya Naidu,
Hon ble Minister of
State for Water Resources,
Shram Shakti Bhawan
Rafi Marg, New Delhi-110001

2. Dr M.S.Reddy,
Secretary (WR),
Ministry of Water Resources
New Delhi - 110001

3. Shri N.Suryanarayanan,
Commissioner (PP),
Ministry of Water Resources
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4. Shri P.C.Mathur
Commissioner (WM),
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5. Shri N.V.V.Char,
Commissioner(ER),
Ministry of Water Resources,
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6. Shri Kanwal Nath,
Joint Secretary & F.A.
Ministry of Water Resources,
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7. Dr. V.S. Dinkar
Senior Joint Commissioner (CAD),
Ministry of Water Resources,
New Delhi

8. Ms Veena Jain,
DPIO,P/B M(WR)
New Delhi

9. Shri J.P. Mamgain,
PS to Minister (WR)
New Delhi

10. Shri N. Shankar
PA to Minister of State (WR)
New Delhi

11. Shri Ramesh Chandra
Chairman, INCID & CWC,
New Delhi

12. Shri Zafarul Hasan,
Member (WP&P), CWC,
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13. Shri G.N. Murty
Chief Engineer
CWC, New Delhi

14. Shri V.V. Badrinarayan
Chief Engineer
CWC, New Delhi

15. Shri K.S. Rana
Chief Engineer
CWC, New Delhi

16. Shri V.K. Mathur
Chief Engineer
CWC, New Delhi

17. Shri M.N. Mathur
Director
CWC, New Delhi

18. Shri S.K. Choudhuri
Director (FCC)
CWC, New Delhi

19. Shri C.D. Khoche
Director (IP)

20. Shri M. Gopalakrishnan
Director (R&D-I)
CWC, New Delhi

21. Shri S.K. Das
Director (Trg)
CWC, New Delhi

22. Shri U.K. Ghosh
Director
CWC, New Delhi

23. Shri P.K. Saha
Dy. Director (IP)
CWC, New Delhi

24. Shri B.K. Khullar
Dy Director
CWC, New Delhi

25. Shri R. Janardhana Babu
Dy Director
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26. Shri N. Parthasarathy
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WAPCOS (India) Limited
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27. Shri R. Balasubramanian
Chief Engineer (Com)
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28. Shri E.V. Jagannathan
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Senior Scientist &
Dy. Commissioner (H),
IARI, Krishi Bhawan,
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34. Shri R.S. Doharey
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35. Shri Manoj Khanna
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36. Shri A.D. Mohile
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37. Shri Rakesh Hooja
Secretary (CAD & WU Deptt) &
Commissioner & Special Secretary,
Govt. of Rajasthan,
Jaipur -302005 Rajasthan

38. Shri P.D. Bhatnagar
Secretary (Gen)
Consortium of Scientists

39. Shri S. Ghore
Joint Secretary
Govt of Orissa, Bhubaneshwar

40. Shri P.C. Sharma
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47. Shri Devdatta
Director (Horti)
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48. Shri Gopal Chauhan
Director (WRDTC)
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49. Shri N.V. Pundarikanthan
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61. Shri G.P. Mishra
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Sprinkler Irrigation System
(Courtesy : M/s Jain Irrigation)

Shri P.V. Rangayya Naidu,
Hon'ble Minister of State
for Water Resources
Lightening the Lamp for
inauguration of the Seminar

Shri P.V. Rangayya Naidu,
Hon'ble Minister of State
for Water Resources
addressing the participants

Shri N.Parthasarthy
Chairman & Managing
Director, WAPCOS
(India) Ltd. receiving a
copy of the final draft
of the Report from
Prof. P.B.S.Sarma

Back Cover : HDPE Sprinkler System for Sugar Cane Crop.

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