

MAXIMIZING THE BENEFITS FROM WATER AND ENVIRONMENTAL SANITATION

Training for sudden changes in technologies

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Irrigated agriculture is important in semi arid regions of India, including the state of Maharashtra. However at the same time as the water is a scarce commodity in this region, its efficient utilisation is important. Conventionally surface irrigation methods are adopted for irrigating the crops. However the irrigation requirements of these methods is high due to unavoidable losses in the process of conveyance and application. Hence the farmers in the region have begun to shift towards more water efficient methods such as drip irrigation method. But the adoption of drip irrigation methods needs a high level of technical knowledge compared to conventional surface irrigation methods. The extension (training) service of State Departments was not equipped to train the farmers and hence initially the adoption of drip irrigation system proved to be difficult and instances of reverting back to surface irrigation system from drip irrigation system were reported. Under such situations, it was necessary to develop and adopt the training strategies that are effective in the circumstances of rapidly changing technologies. This paper compares the conventional surface irrigation and drip irrigation methods; narrates the causes behind shifting from surface to drip irrigation methods and presents the training strategies that were devised and adopted during this shift.

Keyword: training strategy, drip irrigation, changing technology

Introduction

AGRICULTURE is the backbone of the Indian economy. As Planning Commission, Government of India quotes (Planning Commission, Government of India, 1998):

“Agricultural growth is a pre-requisite for the economic and social development of our country. Agriculture contributes 28% of GNP, about 60% of employment and is the primary source of livelihood in rural areas which account for 75% of India’s population and 80% of its poor.”

Further the contribution of irrigation to Indian agriculture is remarkable. The following quotes from the Planning Commission, Government of India (1998) summarizes the importance of irrigated agriculture in India:

“The irrigated agriculture, contributes nearly 56% of agricultural output. Addressing the irrigation sector’s current performance problems will thus be a central element of future strategy for agricultural development.”

India has the largest irrigated area among all the countries in the world. This has greatly contributed to the increase in food grains production from 51 million tonnes (Mt) in 1950-51 to 198 Mt in 1996-97 at a compound annual growth rate of around 3 per cent. According to Planning Commission, Government of India (1998), about 60% of the food grains production has come from the irrigated area that constitutes about one-third of the total cultivated area.

The ultimate irrigation potential of the country from major and medium projects is estimated as 58.46 M ha and

from minor irrigation projects is estimated as 81.43 M ha, of which 17.38 M ha is from surface water minor irrigation schemes and 64.05 M ha is from ground water schemes. The total ultimate irrigation potential is thus 139.89 M ha, out of which 75.84 M ha is surface water potential and 64.05 M ha is groundwater potential. Against the 95.4 M ha of total irrigation potential created, only 85.4 M ha is being utilised. However, according to the Ministry of Agriculture’s Land Use Statistics, the gross irrigated area is only 75.55 M ha (1998-99) (Planning Commission, Government of India, 1998).

According to 1996-97 statistics, the net sown area of the country was 142 M ha and gross sown area was 190.50 M ha. The gross irrigated area in India is 75.55 m ha, which is approximately 40% of gross sown area. This, despite the fact that the irrigation facilities created in the country can meet the requirements of 95 million hectares.

Similar situation exists in Maharashtra State, the 3rd largest state situated in the southwest of India. The state economy is dependent upon agriculture production. Agriculture has been the prominent occupation to provide food and fibre to the growing population of the state. Water Resources Department, Maharashtra Government quote (2004):

“It is therefore agriculture and allied activities play role in the state economy. However the share of Agriculture and Animal husbandry in the Gross State Domestic Product has remained comparatively low, around 13 per cent. It is therefore necessary to increase the agricultural production and productivity of the crops, which forms the major basis of the rural development.”

The report further recognises the importance of irrigated agriculture. The geographical area of the state is 30.8 M ha, with cultivable area of about 22.5 M ha (Water Resources Department, Maharashtra Government, 2004). According to Sodal (2004) the state has created approximately 3.7 M ha irrigation potential by 2000-01. However only 1.3 M ha area is currently irrigated.

There are several reasons for the gap in irrigation potential created and utilised. These can be attributed to less yield from reservoirs than expected, more non-irrigation use than that planned, higher conveyance losses and less water use efficiency, improper and inadequate means of supplying water to the fields etc.

This paper deals with the aspect of means of supplying water to the fields. As will be shown later in the paper, the under-utilisation due to improper and inadequate means of supplying water to the fields is not due to lack of the technologies but due to the lag in 'technology development' and 'transfer of technologies to farmers' field'.

This paper shows the need of progressing 'technology development' and 'technology transfer' hand in hand. This is explained with first and third authors' experiences on the adoption of one of the efficient means of supplying water to the field by the farmers in the water scarce region of Maharashtra, India. The paper starts with the brief description of different existing irrigation methods (also called as conventional methods of irrigation) and how the technologies of these irrigation methods are traditionally transferred to the farmers' field. The paper further describes micro-irrigation methods that can save water to the extent of 10-50% and increases the crop yield by 10-20% over conventional methods (Magar and Firake, 1991) and the circumstances that led to the almost swift adoption of this system by some farmers. The paper closes with the description of different capacity building approaches that were adopted for effective implementation of this method in the field and the author's observations on the effectiveness of these approaches.

Irrigation Methods Practised in Maharashtra

The conventional irrigation methods that are practised by the farmers in the state of Maharashtra are surface irrigation methods (flood, border, check basin and ridges and furrow irrigation methods) and micro irrigation methods are drip and micro sprinkler irrigation methods. In addition to this, the farmers also practice the sprinkler irrigation methods. Sprinkler and micro irrigation methods are pressurised irrigation methods and hence are adopted only for irrigation by groundwater.

In India the use of drip irrigation started in 1970s with experiments in Mahatma Phule Krishi Vidyapeeth (Agricultural University) (MPKV), Rahuri (Maharashtra) and Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The micro sprinkler irrigation methods were introduced in mid 90s by MPKV with experiments on crops such as groundnut,



Figure 1. Flood irrigation

onion and garlic and by irrigation companies operating in the region.

The area under drip irrigation in India in 1985 was 1000 ha and increased to 70 860 ha in 1991 (FAO, 1997). This area further increased to 225,000 in 1998 (Thakkar, 1999). Almost 50% of area under drip irrigation is in the State of Maharashtra. But still it constitutes less than 1% of total irrigated area. This is quite negligible compared to the total area under cultivation.

Conventional methods of Irrigation in Maharashtra, India

Flood Irrigation

Flooding is one of the oldest irrigation methods practised in Maharashtra. This method does not have any layout for irrigation (Fig. 1). In this method a shallow dam is raised around the entire perimeter of the area to be irrigated. Water is then allowed to flow over the soil until the dammed area is completely covered. It covers the entire field and water moves almost unguided. Water is allowed from the channel into the field without much control on the flows into channel and flows into field. There is also no control on the application of water. Hence in flooding much more water is applied than that required to cover the entire field to be irrigated. Thus uneven distribution and low water application efficiency are the common drawbacks of this method.

In addition to wastage of water, the other associated drawbacks of this method are reduction in crop yield (due to prolonged periods of water logging), water logging and salinity. In 1960s and 70s, the surface irrigation methods that apply water efficiently to the fields started replacing flood irrigation realising the need to increase the food production.

Check-Basin Method

Basin irrigation (Fig. 2) is the most common form of surface irrigation, particularly in regions with layouts of small fields. In this method the field is divided into small plots surrounded by small bunds on all the four sides. Water from head channel is supplied to the field channels one after the other. Each field channel supplies water to two rows of check basins and water is applied to one basin after another. This method is

adopted when the field is quite large and it is not easy to level the entire field. Basins are typically square in shape but exist in all sorts of irregular and rectangular configurations. The basin may be furrowed or corrugated, have raised beds for the benefit of certain crops, but as long as the inflow is undirected and uncontrolled into these field modifications, it remains a basin. The advantage of this method is that the water can be applied uniformly and effectively. It is suitable for close growing crops like groundnut, wheat, finger millet, pearl millet, Para grass etc. The disadvantages are more labour is required, more land is wasted under channels and bunds. Inter-cultivation is difficult due to bunds.



Figure 2. Check basin irrigation

Border irrigation method

In this method (Fig.3) the field is divided into a number of strips by forming bunds of around 15 cm height. These parallel earth ridges are called borders, and are formed to guide a sheet of flowing water across a field. The area between two borders is the border strip. Water is applied to individual borders from small hand-dug checks from the field head ditch. When the water is shut off, it recedes from the upper end to the lower end. Sloping borders are suitable for nearly any crop except those that require prolonged ponding. Soils can be efficiently irrigated which have moderately low to moderately high intake rates. The size of border strips depends on stream size, soil structure and slope of the land. This method is suitable for close growing crops and medium to heavy textured soils, but not suitable for sandy soils.



Figure 3. Typical layout of border irrigation method

Furrow irrigation method

Furrow irrigation (Fig. 4) avoids flooding the entire field surface by channelling the flow along the primary direction of the field using 'furrows,' 'creases,' or 'corrugations'. Water infiltrates through the wetted perimeter and spreads vertically and horizontally to refill the soil reservoir. Furrows are often employed in basins and borders to reduce the effects of topographical variation and crusting. The distinctive feature of furrow irrigation is that the flow into each furrow is independently set and controlled as opposed to furrowed borders and basins where the flow is set and controlled on a border by border or basin by basin basis.



Figure 4. Typical layout of furrow irrigation method

Furrows provide better on-farm water management flexibility under many surface irrigation conditions. The discharge per unit width of the field is substantially reduced. A smaller wetted area reduces evaporation losses. The furrow irrigation enjoys higher application efficiencies than borders and basins. The disadvantages include more labourers, difficulty in moving farm implements, erosion etc.

Efficient Practice of surface irrigation methods

There are unavoidable irrigation losses associated with surface irrigation methods. These are conveyance losses in field channel network and deep percolation losses during the application of water. The irrigation losses increase greatly if these methods are not adopted properly. For appropriate adoption of these methods, the layouts and design of these methods are important. However layouts and design vary with crops and soils. The important design parameters are length, stream size per unit width of border, longitudinal slope and cut off time for border irrigation methods; longitudinal slope, furrow width, cut off time and stream size for furrow irrigation method and basin size and time of application for check basin method irrigation. The typical values of these parameters for border irrigation method are presented in Table 1.

During 1960s and 70s when there was large scale shifting from flooding to surface irrigation methods in Maharashtra,

Table 1. The typical values of design parameters for borer irrigation method

Soil type	Length (m)	Slope (%)	Stream size (lps per m width of border)
Sandy and sandy loam soils	60 - 120	0.25 - 0.60	4 - 15
Medium loam soils	100 - 180	0.20 - 0.40	5 - 10
Clay and clay loam soils	150 - 300	0.05 - 0.20	2 - 4

Ref: Michael, 1978

there was need to standardise the design parameters of each method for different crops cultivated on different soils in different agro-climatic regions of the state (development of technology), and then transfer these technologies to fields by training the trainers and then farmers (transfer of technology). The technologies were developed by the Agricultural Universities and Research Institutions while the transfer was effected by incorporating the technologies in the course curricula of Agricultural Universities, training the staff at appropriate level from development agencies (Department of Agriculture and Department of Irrigation) and the staff of development agencies transferring the technologies to farmers' field by training them to adopt the technology by several means.

Shift to drip irrigation methods

During the past several decades, increasing water demand for irrigation has been met by developing new sources of water. However, the technical, economic and environmental costs associated with the continued development of new sources make this approach undesirable for fully meeting future growth. On the other hand, in many states of India, the allocation of water for irrigation is viewed as a low priority. As a result, more recently, it has received a reduced share of the total supply due to increased demand from higher valued uses such as industrial, domestic and recreational. For example, in developing countries the share of water for agricultural uses was 90% in 1995 and is expected to reduce to 70% in 2020 (Pinstrip-Andersen et al., 1997). The "Task force on Micro-irrigation" in India in their report (Government of India, 2004) in their report state that:

"The requirement of water by different sectors by 2025 is estimated to be 105 M ha m, but the share of water for agriculture is expected to get reduced from the present level of 84 per cent to 69 per cent by 2025. On the other hand, the demand for water for agriculture purposes is estimated to increase from 470 BCM in 1985 to 740 BCM in 2025. During the same period, the demand for non-agricultural use of water will multiply four fold, from 70 BCM to 280 BCM."

Constantly increasing population in these countries further increases the pressure on irrigated agriculture to produce more food, especially in view of 2-3 times greater productivity of irrigated agriculture than rain-fed agriculture. The problem is further aggravated by the excessive groundwater use. An article published in Frontline (by Ramachandran, 2000) state that:

"The rapid increase in groundwater-based irrigation using tubewells that are more than 150 metres deep and high-power pumps in recent times is one of the many reasons for groundwater depletion and the drop in the groundwater table. The area covered by groundwater-based irrigation [in India] has increased from 6.5 million hectares (Mha) in 1950-51 to 40 Mha. An annual decline in the water table of up to 2 m is considered normal and can cope with even a deficient rainfall the following year. A decline of up to 4 m is a cause for concern and above 4 m is a stress situation. The Central Ground Water Board (CGWB) describes the current situation as a stress situation. However, there are reports that unregulated overdraft has resulted in water tables dropping 10 to 20 m in several areas in Gujarat."

Hence there is a need to work towards making available water supplies for irrigation more efficient and productive. There are many ways to improve the efficiency of available water to increase agricultural production in an irrigation scheme. These include improving hardware of the scheme (reservoir desedimentation, raising the dam height, developing the catchment area, lining of canal network, installation of water regulatory and measurement structures, repairing and enhancing maintenance of existing water delivery system, development of on farm structures, land levelling, automation etc.), adopting water saving irrigation methods (pressurized irrigation methods such as sprinkler and drip, improvements in traditional irrigation methods such as skip furrow irrigation method, surge flow irrigation etc) and improving software of the scheme (adoption of appropriate water distribution methods such as rotational water supply or on demand water supply, developing optimum allocation plans for land and water resources to different crops in the irrigation scheme, institutional reforms, improving capital related activities, improving crop related management practices, etc). These options are generally not alternatives but often applied together.

Thus in the situations of water scarcity and increasingly declining levels of groundwater, the option of adopting irrigation methods that save water proved to be attractive option for policy makers and farmers for last two decades. Both Central and State Governments offered subsidy schemes for adopting drip irrigation in India. Maharashtra started providing subsidy from 1985-86 onwards. Central subsidy schemes

started during the year 1990-91. Subsidy varies with farmers landholding size. However, 50% of capital cost is provided as a subsidy for farmers who adopt drip method of irrigation. As a result of the subsidy scheme and the water saving ability of the drip irrigation method, this method became quickly popular amongst the farmers in water scarcity region of Maharashtra. Several “Drip Irrigation Companies” also mushroomed in the region for supplying the drip irrigation sets to the farmers. Thus the introduction of drip irrigation technology in the field was almost rushed.

However the adoption of drip irrigation methods in field needs the high level of knowledge in design, operation and maintenance, compared to surface irrigation methods. The typical layout of drip irrigation system is shown in Figs. 5 and 6. The complexities in adoption of drip irrigation system can be seen when this layout is compared to those with surface irrigation layouts (Figs 1 to 4). The agencies responsible for transferring the drip irrigation technology were not quite prepared for two reasons. Firstly, though the drip irrigation method was available in terms of its physical components, but the information on the design and operation was almost non existent. Secondly, the drip irrigation method differs in many aspects from the conventional surface irrigation methods for which the personnel from Development agencies were not trained and equipped. Hence initially the problems were encountered with the adoption of drip irrigation system. Some of these ha a major impact on crop production such as: blowing away of drip irrigated orchard plantations; and only vegetative growth of crops and less bearing of fruits in drip irrigated plantations.

The real challenge was then for the Agricultural Universities and Research and Training Institutions in the region to train the personnel from development agencies and farmers for appropriately disseminating this technology without losing much time.

Training Strategies

The training strategies adopted by one of the Agricultural Universities in the region (Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra) are elaborated in this paper. It should be noted these strategies were not the planned and organised efforts but only motivated by the recognition of



Figure 6. Drip irrigation system for field crops

the benefits of drip irrigation for the region by the different Departments of the University. Thus though the strategies explained in this Section appear to be structured. These were as such based on the needs of trainers and farmers and as and when recognised by the University Departments. The discussions in this Section are based on the observations of first and third authors of the paper.

Identification of the Needs

In Maharashtra the responsibility of transfer of technology rests with the State Department of Agriculture with the jurisdiction over the entire State of Maharashtra. The Agricultural Universities are entrusted with education, research for developing and updating the technologies and extension education activities (Fig. 7). The extension education activities of the University include imparting education as training of extension personnel of the State Department of Agriculture and other Departments. The personnel of the State Department of Agriculture specifically include: Village Extension Workers and Subject Matter Specialists. The extension activities are executed through demonstrations, meetings, discussions, farmers rallies, training, use of publicity material and communication media. The principal objective of all extension education activities is to develop

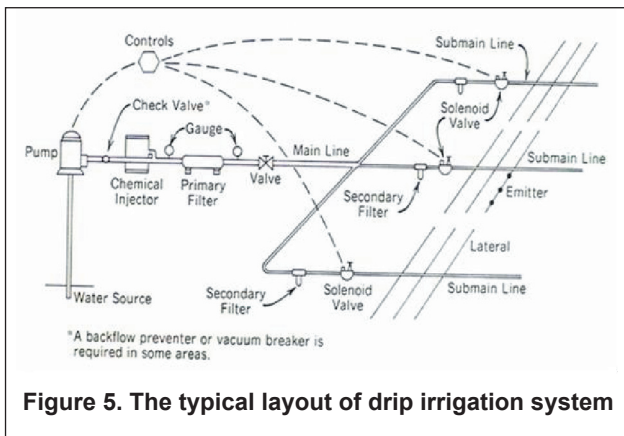
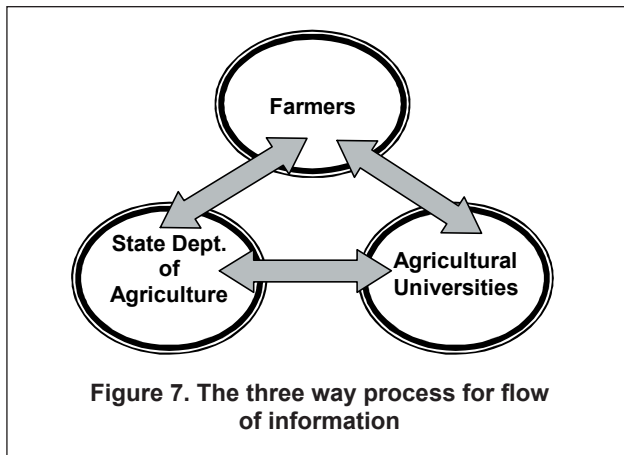


Figure 5. The typical layout of drip irrigation system



necessary skills and knowledge of improved agricultural technology among the extension functionaries to increase the agricultural production.

Capacity building of students for drip irrigation technology

The graduates from the Agricultural Universities are employed in the State Departments of Agriculture, Rural Development and Irrigation at different positions along with numerous other sectors. As stated earlier, these departments are responsible for training the farmers on the appropriate use of agricultural and irrigation technologies. It was intended to build the capacity amongst those students who are interested to pursue their careers with these Departments, to enable them to get involved in the process of technology transfer swiftly by following means.

Development of course curricula: It was felt that the introduction of the separate course related to drip irrigation will make the students aware of the technology and will be helpful to them when they start working with the State Departments for the transfer of technology to the farmers. Recognising the urgent need of this, the courses were included in the course curricula as 'Elective Courses' with more credits to the practical aspects of the drip irrigation technology. The primary aim while developing the curricula was to build the capacity amongst the students that will enable them to guide and train the farmers for better layout, design and operation and maintenance of the drip irrigation system.

Training programmes: As a part of the course requirements, students are required to complete two one-month training programmes. In this case the students interested to pursue their careers with above-mentioned State Departments were encouraged to select drip irrigation industries and farms with drip irrigation installations for training. The training in industries was encouraged to enable the students to understand the manufacturing aspects of different components of drip irrigation systems, that would help them to design the system in the field and advise the farmers on the use of different components of the system. The training in the farms was encouraged to enable them to learn the operation of the drip irrigation system in fields that will eventually help them to guide the farmers on this aspect.

Students' Research Project: The students are also required to complete the research projects as a part of the course during the last two semesters of four-year course. These research projects are rigorous and normally consist of conducting field experiments for full duration of crops, design/modification and development of implements/instruments for agriculture/irrigation, full scale laboratory experiment, computer modelling etc. It was felt that this is the good opportunity to provide students the training on the total package of applying drip irrigation in the field and to generate simultaneously the information required for the adoption of drip irrigation technology for different crops through these projects.

In addition to the recruitment in development departments of State Governments, the students are also employed in drip irrigation industries and start their own business/consultancy. According to the rules of subsidy, these companies have to provide the design and layout of drip irrigation system to farmers. The building of capacity amongst the students by the above stated means enabled these students to perform different activities effectively when working with State Departments or drip irrigation industries and to contribute to increasing agricultural productivity.

It is to be noted here that capacity amongst the faculties of the University was very high as the faculties consisted of four members who had obtained their advance degrees from the USA and Israel and many others who were trained in USA and Israel on drip irrigation technology.

Capacity building amongst farmers and trainers

Training programmes: Normally the Agricultural University organises the training programmes for the personnel of the State Department of Agriculture to train them to transfer the developed or updated technology to the fields. However realising the fact that this process may take more time to get feedback from farmers about the technology, the training programmes were designed and organised to include both the personnel from State Department of Agriculture (especially village level workers) and farmers. This enabled the interaction amongst farmers, University and village level workers. The village level workers could know the problems faced by the farmers on drip irrigation systems during the training programme and the ways to tackle those problems could be sorted out in the training programme by this interaction. In addition to this, the farmers attending these training programmes were expected to play their role in transferring the technology to the neighbouring farmers. Farmers could take guidance on this aspect from the village level workers during the training programme. The feedbacks were useful to revise the training strategies and also to perform the research accordingly.

These training programmes included actual on farm installation of the drip irrigation system, functioning of each component of the system, preparing the irrigation schedules and operating the system. The visits were organised to the fields that were installed with the drip irrigation system for more than 2-3 years. The experience of the farmers on

drip irrigation system, difficulties faced by them in proper adoption of the system and their views on the maintenance of the system were useful for the participants of the training programme.

Demonstrations: The on farm demonstrations of drip irrigation system were organised by the University on its farm and on the farmers' fields for different crops for their full crop season. This enabled the neighbouring farmers to grasp the technology and spread this further. The visits of farmers were also organised on the demonstration site by the State Departments.

Research Programmes

In addition to develop the capacity amongst the farmers to adopt drip irrigation technology, the information on various aspects for different crops cultivated on different soils in different agro-climatic region is also needed for its efficient operation. For example, the spacing between drippers and spacing between emitters for a specified type of soil to wet the desired area; the area to be wetted for different crops for optimum utilisation of water, the irrigation scheduling etc. As the system was introduced suddenly, this information was not available. The information available in the literature was mainly from USA and Israel, where the soil and agro climatological situations are different than in the region. In fact the agriculture and irrigation are location specific and it is essential to generate the information for the specific locations. The University Departments have taken large-scale research programmes to generate this information for most of the horticultural, vegetable and field crops and transfer this to the farmers. As stated above, many such research programmes were initiated through student's research programmes. The guidelines were developed for irrigation scheduling to train the farmers to irrigate their fields by drip irrigation efficiently.

Conclusion on Effectiveness of the Strategies

The effectiveness of the strategies could be seen through the increased productivity in drip irrigation plantations and more adoption of this system in water scarce areas of the region. Drip irrigation has become stabilised in Maharashtra as a technology which farmers operate without difficulties to produce the same or higher crop production as surface irrigation while using much less water. However in the process of emphasizing operation aspects of drip irrigation system, the maintenance aspects were overlooked. One reason was the maintenance problems could not be anticipated in the beginning of adoption of drip irrigation system and hence training needs on this aspect were overlooked in this phase. This resulted in reducing the effectiveness and life of drip irrigation systems. But currently these aspects are being looked in to and accordingly training strategies are being updated.

Thus the flow of information is a three way process as shown in Fig. 7. The farmers' needs are identified through the State Department of Agriculture and farmers themselves by several means including direct feedback, visits, meeting, workshops etc.

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