Dedicated to my Beloved Parents
With Love and
Respect

----PRASHANT

# ECONOMIC EFFICIENCY OF DRIP IRRIGATION IN SUGARCANE PRODUCTION IN THE COMMAND OF THE COOPERATIVE LIFT IRRIGATION PROJECT IN SANGLI DISTRICT

By

**Prashant Prabhakar Inamdar**

Reg. No. 91100

A Thesis Submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH**

RAHURI, 413 722 DIST - AHMEDNAGAR,
Maharashtra State (India)

In partial fulfilment of the requirements for the degree

of

**MASTER OF SCIENCE (AGRICULTURE)**

in

**AGRICULTURAL ECONOMICS**

DEPARTMENT OF AGRICULTURAL ECONOMICS
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI, DIST- AHMEDNAGAR, M. S. (INDIA)

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Maharashtra (India).

1994

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or any other person to any other University or Institute for a degree or diploma.

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Dated : 22nd Sep. 1994

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## CERTIFICATE

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The assistance and help received during the course of investigation have been acknowledged.

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(Dr. N.K. Umrani)

M.P.K.V., Rahuri,
Dated : 30-9-94

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In the context of the limitations on availability of water resources for irrigation and farm level inefficiencies in irrigation water management, the high-tech irrigation methods are expected to play a greater role both in terms of saving of water and increasing irrigation water application efficiency to realize higher crop production. Accordingly, a beginning has been made in Western Maharashtra to adopt drip irrigation technology to irrigate different crops. One good example of such a type of attempt is at Ankalkhop village in Tasgaon tahsil of Sangli district, where biwall drip irrigation unit has been installed on the existing lift irrigation scheme at the auspices of the Vasantdada Shetkari Sahakari Sakhar Karkhana, Sangli to irrigate sugarcane crop on the fields of the member cultivators on a large scale. The benefits of biwall drip irrigation method over surface irrigation method for sugarcane crop have been admired by the farmers to some extent. Systematic efforts have been made in the present study to document additional costs and additional benefits of biwall drip irrigation technology for sugarcane crop at the farm level.

This study was completed under the guidance of Dr. Jg.R. Pawar, M.Sc. (Agri.), P.M.A., Ph.D., Professor of Agricultural Economics at the Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri. It is proud privilege to express my deep sense of gratitude and profound thanks to my research guide for his scholastic guidance, constant inspiration and brotherly love throughout the course of research work.

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While travelling on this path of education, many hands pushed me forth, lips put elixir in my heart, learned hearts put me on right track, lightened by their knowledge and experience. I ever rest thankfully in debt of them all.

(Prashant Inamdar)

M.P.K.V., Rahuri,

Dated : 22nd Sep. 1994

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## ABSTRACT

ECONOMIC EFFICIENCY OF DRIP IRRIGATION IN SUGARCANE PRODUCTION IN THE COMMAND OF THE COOPERATIVE LIFT IRRIGATION PROJECT IN SANGLI DISTRICT

by

PRASHANT PRABHAKAR INAMDAR

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| | | |
|---|---|---|
| Research Guide | :: | Dr. Jg. R. Pawar |
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Efforts were made to study the economic efficiency of drip irrigation in sugarcane production in the command of the cooperative lift irrigation project in Sangli district. The study was based on the quantitative information obtained by survey method from the sample of 90 farm families and the official records of the lift irrigation scheme and biwall drip irrigation unit at Ankalkhop village in Tasgaon tahsil of Sangli district. The farm level information on various aspects of capital investment and resource use structure, production costs, output, gross returns and net returns of sugarcane and other crops grown on the farms of the participating farmers was obtained from sample farmers and the information on total investment costs and operating costs of lift irrigation scheme and biwall drip irrigation unit was obtained through the records available with the office of the concerned project. The data thus collected were compiled and analysed in order to obtain estimates of additional costs and additional returns of biwall drip irrigation technology in sugarcane production; both at the farm level and lift irrigation project level as well. The relative efficiency of biwall drip irrigation and surface irrigation methods was studied


(Contd.....)

through benefit-cost analysis and rate of return of biwall unit vis-a-vis lift irrigation scheme at the farm level, at the biwall drip irrigation unit level and for the entire system level.

The farmers having small size of family and lower proportion of earners have participated more in the installation of biwall drip irrigation unit. There was no specific relationship between size of farm and productivity level of sugarcane. After adoption of drip irrigation technology, the proportion of cultivated area in the total area reduced slightly and there was almost no change in the land use pattern after introduction of drip irrigation technology. Though there was significant increase in the irrigation intensity on introduction of drip irrigation technology on the farms, the cropping intensity decreased slightly because of increased area allocation to sugarcane crop after biwall drip irrigation. The funds required for the installation of biwall drip irrigation unit were raised through loans to farmers from the Sangli District Central Cooperative Bank, funds from the Vasantdada Shetkari Sahakari Sakhar Karkhana and subsidy from the government.

The per hectare use levels of male, female and bullock labour and also, per hectare use levels of manures, chemical fertilizers and plant protection chemicals for the sugarcane crop grown under biwall drip irrigation system were considerably lower than that of the sugarcane crop grown under surface irrigation method.

The cost of production of sugarcane grown under biwall drip irrigation method was higher than that of sugarcane crop grown under surface irrigation method because of increased cost on account of depreciation on laterals and biwall pipes, interest on loan, increase in irrigation water charges and rising prices of inputs. The per hectare yield of sugarcane grown under biwall drip irrigation method was higher than that of the sugarcane crop grown under surface irrigation method by about 24.32 tonnes at the overall level.

The adoption of biwall drip irrigation method for irrigating sugarcane crop did not affect the input use

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structure of other crops (kharif jowar, soybean, groundnut, rabi jowar, wheat, gram and grapes, etc.) to any significant extent. In general, the per hectare use levels of most of the inputs for different crops was slightly high during the latter period.

The adoption of biwall drip irrigation method in place of surface irrigation method for sugarcane crop in the command of the lift irrigation scheme has yielded net additional benefit of Rs. 45732 per annum. There is a scope for increasing the benefits of biwall drip irrigation system in the command by way of increasing the area under drip irrigation with the use of saved water. The water saving was as much as 54.88 per cent because of adoption of biwall drip irrigation system for sugarcane crop in the area.

Because of adoption of biwall drip irrigation method for sugarcane, the participating farmers could get net additional benefit of Rs. 1634.66 per hectare over and above the crop grown under surface irrigation method. At the overall level, the benefit-cost ratio of biwall drip irrigation method worked out to 1.13. The benefit-cost ratio for the entire system worked out to 1.13 and the internal rate of return for the biwall drip irrigation unit was estimated as 30.73 per cent.

For the expansion of 32 hectares of area under biwall drip irrigation by using saved water, the additional investment cost and operating cost required will be Rs 3,78,000 and Rs. 5,89,576, respectively. The proposed expansion plan is expected to yield net additional benefits of Rs. 23,667 and Rs.1,88,091 to the sugar factory and the farmers, respectively. The benefit-cost ratio for the biwall drip irrigation unit and the entire system as a whole works out to 1.36 and 1.17, respectively. The internal rate of return will be 36.02 per cent for the entire system.

In the views of the participating farmers and the management, the biwall drip irrigation method for sugarcane was a very useful and beneficial system. It proved to be profitable for the farmers and management as well. The farmers and management suggested that the existing shortcomings and deficiencies in the implementation of biwall drip irrigation system be removed with immediate effect.

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The biwall drip irrigation system has become an important instrument for increasing sugarcane production, improving economic condition, stabilizing the income and improving overall economic condition of the farmer. The efforts aiming at removal of existing inefficiencies in the implementation of the biwall drip irrigation system for sugarcane would certainly fetch a good dividend to the participating farmers and management of the unit and thereby the entire unit could become an ideal to the others.

# Introduction

# 1. INTRODUCTION

Agriculture requires various inputs like land, water, seeds, labours, fertilizers, etc. Of these inputs, water is the most important and basic input besides land for growing crops. Also, water is the vital need of Man for his various other activities. It is required for drinking purpose and sanitary purposes. Water is an important raw material for industrial processes and it is the source of energy in hydro-power generation. Besides facilitating fisheries and transport activities to some extent, water carries aesthetic value and attracts living beings for recreation. If not controlled and managed properly, water creates problems such as flood hazards, soil quality deterioration, ill health, environmental degradation, etc., which are of serious nature in the context of sustained living conditions to the people and natural resource conservation.

Water is, thus, interlinked with various sectors of development like agriculture, health, industry, power and transport. Among the competing water uses, the use of water for irrigation purpose is the important one. Irrigation means application of water artificially to the plants for satisfying their moisture needs. Irrigation encourages farmers to sow right strains of crops at right time and use other inputs in right quantities in order to realise maximum profits from crop production activities.

## 1.1 Economic Importance of Irrigation

In India, agriculture has held a dominant position in the national economy and the bulk of the population depends on it for living. However, this major occupation has been rendered hazardous periodically by scarcity of rainfall in large area and erratic monsoon elsewhere. Often partial failure or even delayed arrival of monsoon could cause extensive damage to crops, livestock and inhabitants as well in the rural areas. Conscious efforts were, therefore, made from ancient times to supplement deficient rainfall and to mitigate grave consequences of a dry spell by supplying water artificially to the parched fields. Under Indian conditions, irrigation benefits the farmers greatly by lessening risk in growing a crop and by increasing the average yields.

In effect, irrigation is the key input to increased agricultural production in virtually all ~~of~~ over India. For most of the seasonal and perennial crops, conservation of water for irrigation is highly essential to the successful introduction of high risk, modern agricultural production technology, such as improved seeds, chemical fertilizers, plant protection chemicals, etc. (Peterson, 1987). Besides influencing the agricultural production and productivity, the increased availability of irrigation water resources has been the dynamic force behind the phenomenon of increased

capital formation in agriculture and increased employment and income opportunities in the rural areas (Biswas, 1985). The self-sufficiency in foodgrains and other agricultural products, the progress of agro-based industries such as sugar and textile and quantum of foreign exchange earnings from exports of the products like jute, tobacco, lac, tea, oilseeds, etc., depend on the development of agriculture which is determined largely by irrigation. The goal of producing more agricultural production per unit of land, labour and capital can be achieved by way of having more canals, wells, tanks and other irrigation water development programmes.

## 1.2 Development of Water Resources for Irrigation

During the last four decades, the Government of India and the state governments have invested enormous amounts of resources in the development of large surface irrigation systems and small irrigation works as well. At the same time, farmers have made conscious efforts to harness groundwater and surface water resources for irrigation purposes by way of construction of tube wells and open dug-wells and installation of lift irrigation units either on individual or cooperative basis. Because of all such efforts, the irrigation potential in India has increased from 22.6 million hectares before 1951 to about 68 million hectares by 1985 which was just sufficient to

irrigate one-third of the cropped area. Out of 1769.20 lakh hectares of cultivable land in the country, 556.56 lakh hectares was under irrigation by all sources in 1986-87.

So far as the Maharashtra State is concerned, the net irrigated area was 8.51 lakh hectares in the State in 1951-52. With the sustained efforts for exploitation of potential surface water and groundwater resources during the Plan period, the net irrigated area increased to 24.43 lakh hectares in 1989-90 and 27.16 lakh hectares in 1991-92. The major source of irrigation in Maharashtra State is wells; followed by canals, tanks and other sources. The proportion of irrigated area by wells to the net irrigated area was the highest (54.23 per cent) among all the sources, in 1989-90.

Among all the States in India, Maharashtra State possesses prominent position in regard to exploitation of surface water for irrigation purpose with the help of lift irrigation units. A large number of lift irrigation units have been established on the cooperative and private basis. A number of cooperative lift irrigation units reached to 2886 in 1988 which was 119 in 1961, and the area irrigated through lift irrigation has reached to 1,90,000 hectares from 4,700 hectares during the same period. Moreover, the lift irrigation units have been proved to be the blessings

to certain areas which do not possess any possibility of irrigating the fields either by surface water or ground-water sources.

## 1.3 Irrigation Water Use Inefficiency at the Farm Level

The available empirical evidence reveals that near about 40 per cent of the irrigation potential has remained to be exploited as yet at the national level. The situation in Maharashtra is relatively more serious since nearly half the irrigation potential of the State has not been exploited so far. Associated with the phenomenon of underexploitation of irrigation potential, there have been several problems relative to irrigation water uses such as underutilization of irrigation potential already created through massive investments and efforts, inefficient utilization of irrigation project facilities, inequitable distribution of system benefits and other serious consequences of waterlogging, soil quality deterioration, environmental degradation, etc.

Moreover, the occurrence of the above problems is mainly due to the inefficient irrigation water management practices at the various levels. Especially, the drawbacks in the irrigation water use practices at the farm level are of serious nature. Owing to limitation on availability of irrigation water, there is a tendency among the farmers of

diverting available water resources in favour of high pay-off crops as well as of using lesser quantities of various yield increasing inputs and excessive quantities of water by resorting to illegal means.

## 1.4 Application of New Technology : Biwall Drip Irrigation for Sugarcane

Among the crops grown under irrigated conditions in Maharashtra, sugarcane is the most important cash crop in the economy of the State. Sugarcane shares a little over one-fourth of the gross irrigated area and receives more than 80 per cent of the total irrigation water supplies in the State. The area under sugarcane was 34.30 lakh hectares in India and 3.83 lakh hectares in Maharashtra in the year 1990.

It is observed that the area under sugarcane is increasing very slowly in Maharashtra. The area under sugarcane was 1.56 lakh hectares during 1960-61. It increased to 2.04 lakh hectares in 1970-71 and to 3.19 lakh hectares in 1980-81. During the period from 1981-82 to 1991-92, the area under sugarcane in Maharashtra has increased from 3.45 lakh hectares to 4.59 lakh hectares. There are limitations on increasing area under sugarcane in the State because of inadequate irrigation water supplies. Besides sharing relatively higher proportion of irrigated area and total irrigation water supplies as

well, sugarcane crop has been associated with several problems especially in terms of its declining productivity and production resulting from use of excessive irrigation water. For increasing sugarcane productivity, the emphasis has to be on proper utilization of irrigation water, adoption of new varieties and use of improved production technology.

Water is the most precious commodity in our country and particularly in Maharashtra State. One should, therefore, use available irrigation water resources very efficiently. It is observed that farmers use lot of water for sugarcane by flow method which in turn creates problems like waterlogging, deteriorating soil conditions, etc. The traditional flow method of irrigating sugarcane crop is characterised by uneven distribution of water which results in poor yields. Besides, the exposure of crop to cyclic changes of water stress and over watering disturbs physiological activities and thereby hampers crop production. The effective area of land also decreases by 10 to 15 per cent due to irrigation layouts. Over irrigation results into gradual built-up of waterlogging and progressive built-up of salinity making soils unsuitable for cultivation. Loss of nutrients due to deep percolation and seepage compell farmers resort to higher use levels of fertilizers and irrigation. There are also instances of

slow and gradual change in physical properties of soil due to top soil erosion at field at higherelevation and unwanted silting at low levels. Inefficiency in irrigation water use also results into undesirable weed growth and increasing cost of production of crops. Moreover, the magnitudes of disadvantages of flow irrigation methods vary according to soil profile and topography of fields.

The available empirical evidences reveal that the productivity of sugarcane has been declining because of inefficient irrigation water management practices at the system and farm levels. The solution to these problems lies with the wide-spread adoption of improved water application technologies and water management practices at farm level and improvements in water delivery systems. Fortunately, there has been some kind of awareness in this regard among farmers in Western Maharashtra. The technology of applying water to root zone area of sugarcane through biwall drip irrigation system seems to have caught minds of the enterprising and innovative farmers in recent days. The advantages of biwall drip irrigation technology in terms of having control over optimum combinations of irrigation water with other yield increasing inputs and saving water to bring additional cropped area under irrigation have been admired by a large number of farmers. Some of other advantages are : (1) controlled application of

water as per needs of plant at low pressure to limited soil areas, (2) water saving up to 50 to 60 per cent by reducing total evaporative losses, reduction in runoff, and controlling deep percolation losses below root zone, (3) soil erosion is minimal due to practically no runoff of surface water between crop rows, (4) weed growth is minimal since limited soil surface is wetted, (5) water loss through transpiration is negligible since weed population is low, (6) development of surface crust and destruction of surface soil structure are avoided and infiltration rate is matched at desired levels by using low application rate drip system, (7) limited soil wetting permits the uninterrupted cultural practices, all interculturing operations, spraying of chemicals, (8) saving of fertilizers by monitoring the supply of nutrients as per the need of crop is possible and cost of application is reduced, (9) many soil borne pathogens and pests can be controlled by mixing fungicide or pesticide in irrigation water, (10) better yields and quality of products are obtained, and (11) moderately saline water can be profitably used for irrigated agriculture by adopting drip system.

The use of drip irrigation has been started in India since 1980 on experimental basis mostly in Tamil Nadu, Maharashtra and Karnataka States. Now-a-days, Maharashtra is on the top in the country in respect of drip irrigation.

More than 2500 acres of land is under drip irrigation in Maharashtra.

Drip irrigation is found to be very suitable in daily application of water or soluble fertilizers to the crops. It delivers sufficient water and nutrients to the plant roots according to their needs. This can be achieved by applying water drop by drop at the root zone of the plant slowly and frequently under low pressure at predetermined rate through emitting devices. Micro-irrigation includes irrigation system using strip tubings (bi-wall and leaky pipes), emitters like micro-tubes (drippers, turbokey, E-2, etc.) or spray jets and microsprinklers as emitters.

Now-a-days, the use of dripper is costlier one as compared to the use of micro-tubes. Moreover, there are less problems of clogging of micro-tubes as their inner diameter is comparatively larger than that of drippers. The biwall system is the latest and cheapest advanced technology in irrigating the row crops effectively with minimum water losses. There are two parts in biwall pipe. One is big called as main line and another smaller one called as subsidiary line. There are no separate drippers because smaller holes are prepared on biwall pipe itself. Due to these advantages farmers are adopting micro-tubes and biwall system on a large scale.

## 1.5 Topic of the Study

The adoption of biwall drip irrigation technology by the farmers seems to have been on an individual basis so far. Recently a large scale biwall drip irrigation unit has been established in Ankalkhop village in Tasgaon tahsil at the auspices of the Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli. This unit has been established on the existing cooperative lift irrigation project. Around 235 farmers derive benefits of biwall drip irrigation technology. They irrigate about 148 hectares of sugarcane land by biwall drip irrigation technology. On enquiry, it is found that sugarcane crop grows well with this technology. The participating farmers have reported several advantages of drip irrigation system and most of them confirm to the findings of experiments on drip irrigation conducted at research stations. It is, however, true that systematic efforts have not been made so far to quantify advantages of drip irrigation technology in sugarcane production in comparison with the associated costs of establishing a large scale biwall drip irrigation system on cooperative lift irrigation scheme. It is, therefore, proposed to undertake a study on "Economic Efficiency of Drip Irrigation in Sugarcane Production in the Command of the Cooperative Lift Irrigation Project in Sangli District" for detailed analysis.

## 1.6 Objectives of the Study

Following are the objectives of the study.

(1) To estimate investment and operating costs of biwall drip irrigation in the command of the cooperative lift irrigation project.

(2) To study relative economics of sugarcane production with biwall drip irrigation and flood irrigation methods in the command of cooperative lift irrigation project.

(3) To assess economic benefits and judge economic efficiency of biwall drip irrigation unit in the command of the cooperative lift irrigation project.

## 1.7 Hypotheses of the Study

It is proposed to test the following hypotheses in order to fulfil the requirements of the objectives of the study.

(1) Installation of biwall drip irrigation unit on the existing cooperative lift irrigation scheme results into higher investment costs.

(2) Adoption of biwall irrigation method results into increase in yield of sugarcane and decrease in quantities of irrigation water, labour and fertilizer for sugarcane crop as compared to the surface irrigation method.

(3) Additional benefits accruing to the farmers and sugar factory due to installation/adoption of biwall drip irrigation unit outweight the additional costs.

## 1.8 Utility and Scope of the Study

The study is centred around comparison of costs and benefits of biwall drip irrigation technology in sugarcane production with those of traditional irrigation practices. The findings of the study will be useful to policy makers/ planners for determining appropriate water management schemes. The study will be useful to farmers for deciding proper irrigation water management practices to conserve irrigation water and increase production. The financial institutions which supply credit would get information regarding the economic feasibility of the technology. Thus, the study will help them for financing where repayment is assured. The findings will be useful to development agencies for devising appropriate irrigation water management strategies.

The findings are restricted to specific objectives stated above and the area selected for the study. However, the conclusions of the study with some modifications could be applicable to similar irrigation projects having similar topography and other agro-economic situations. The study is based on the information of only one crop of sugarcane, and therefore, the study results be viewed accordingly.

# Review of Literature

# 2. REVIEW OF LITERATURE

It is always better for the researchers to review relevant literature in order to have a theoretical frame-work for designing their research work on scientific basis. It also provides guidance to the new researchers in right direction by giving proper understanding of related concepts, and methodological and analytical issues. Therefore, scanning of literature related to the problem under study forms an integral part of any systematic research work. This chapter gives a brief account of the studies which were carried out by different research workers in the past in the subjects closely related to the topic of the study.

As a matter of fact, water resources have attracted minds of a large number of scientists of different disciplines, engineers, planners, social workers and general populace all over the world since a long time. There is a good body of literature relating to potential water resources, water qualities, water development and use techniques, water demand, water use efficiency/inefficiency as well as social, economical, political, environmental water impacts, importance of water and irrigation, problems of irrigation, need for effective improvements in irrigation techniques, water requirements of sugarcane, relative efficiency of drip irrigation, etc. The aspects of

development and use of water resources for agricultural purposes have been studied by the scientists and planners in their own ways by using multidisciplinary approaches as well.

In view of the vast body of literature on development and use efficiency of water resources, it would be more appropriate to concentrate on a limited number of studies that relate to improvement of irrigation water use efficiency at the farm level through adoption of drip irrigation technology. For the sake of convenience, the available reviews have been classified into the following broad categories :

2.1 Importance of irrigation,

2.2 Irrigation methods and associated problems,

2.3 Inefficiency of irrigation water use,

2.4 Need for effective improvements in irrigation techniques,

2.5 Water requirement of sugarcane,

2.6 Relative efficiency of drip irrigation, and

2.7 Problems of drip irrigation.

## 2.1 Importance of Irrigation

The development of water resources for irrigation

and drinking purposes has been practised since ancient times. The modern techniques of development of water resources, however, became popular from the beginning of the 20$^{th}$ century. The importance of irrigation has been recognised by all in the context of its magnificent contributions to increases in cropping intensity, crop yields, resource use levels, income and employment.

Knowles (1943) has rightly pointed out that irrigation works have made security of life and increased the crop yields and the value of land revenue derived from it. The irrigation works have lessened the cost of famine relief and helped to civilize the regions. While emphasising the importance of irrigation, the 'Famine Enquiry Commission' stated that, among all the measures that may be adopted to increase the area under cultivation and the yield per acre, the first place must be given to the supply and conservation of water (Anonymous, 1945).

Mellor et al. (1968) indicated that irrigation benefits the farmers by lessening risk of growing crops and increasing average yields. Singh (1973) showed that, with the availability of irrigation facilities, the farmers can adopt high yielding variety programme, make a more intensive use of land and follow a cropping pattern which requires more water but gives higher return and yield per hectare.

Gadgil (1948) pointed out that in an agrarian economy, irrigation accelerates the process of capital formation in agriculture. Investment in an irrigation project results in creation of additional employment, improvement of crop productivity and increase in crop production. Ramlingam (1963), Shah (1963), Bagi (1981), Bisalish (1984) and Gurjar (1990) tried to study empirically the farm level impact of irrigation in different parts of the country. They observed that irrigation lifts up an agricultural economy from subsistence to more prosperous agriculture which is a manifested in higher production. The development of irrigation helps to raise the general level of output of the farmer producer through higher yields as a result of injection of larger inputs facilitated by irrigation. Irrigation raises yield per unit area by inducing use of high yielding varieties and other complementary yield raising inputs viz., chemicals, fertilizers and pesticides. It leads to expansion of gross cropped area by resorting to multiple cropping practices. With full irrigation, farmers can go for commercial crops and new crop production technologies which require greater investments, and get much income from them. The technical and allocative efficiencies are also higher on the irrigated farms. Thus, irrigation is an important factor influencing the cropping pattern, crop yield levels and the income of the farmer.

Sinha (1978), Deo (1979), and Senkhayan and Singh (1985) studied the impact of lift irrigation on cropping pattern and crop yields in Haryana, Maharashtra and Punjab, respectively. A positive relationship was observed between irrigation facilities and intensity of cultivation. There is also change in rabi-kharif ratio of cultivation. The yield levels in both irrigated and non-irrigated conditions showed dissimilarity and often these were higher in the old irrigated areas than in the newly irrigated areas.

## 2.2 Irrigation Methods and Associated Problems

Shahane et al. (1954) indicated that 2 types of irrigation methods are being used widely, and those are (a) flow irrigation, and (b) lift irrigation. In effect, the flow irrigation is of two types i.e. (i) perennial system, and (ii) innudation system. Irrigation water is also applied by another two methods viz., (i) surface irrigation system, which includes (1) flooding method, (2) border method, (3) check method, (4) basin method, (5) furrow method; and (ii) sub-surface irrigation system. Among these methods, furrow method is popular for sugarcane and used by the farmers. Sub-surface system involves (1) natural sub-surface and (2) artificial sub-surface methods.

While comparing costs of lifting water from well, Apte and Mulla (1963) observed that electrically operated pumps are more economical than oil engine pumps. According

to Misra (1968), canal is undoubtedly the cheapest source of irrigation. His empirical work revealed that the cost of irrigation in case of sugarcane was higher under government tube wells, private tube wells and masonery wells fitted with persian wheels than that under canal by 34.40, 4.81 and 87.16 per cent, respectively.

Patel and Patel (1969) studied the economics of rural electrification and lift irrigation in Gujrat and observed that electrified pumps are cheaper than diesel pumps for operation at any level. Pawar (1970) observed in Sangli district that the irrigation charges are relatively more in the case of lift irrigation on river followed by oil engine pumps and electric motor pumps on wells.

## 2.3 Inefficiency of Irrigation Water Use

Although water is available to irrigate the land, it is not being used systematically. A lot of water is wasted and there are some problems of irrigation. Some studies on this aspect are given below.

Kaul (1974) indicated that the utilizable water resources constitute only one-third of the total availability of water resources from surface run-off of precipitation which drains into and flows down into river and groundwater.

Khare (1979) showed that most of the additional water resource created during 1960 to 1970 was being devoted to sugarcane production in Maharashtra. Although 1.10 per cent of the cropped area was devoted to sugarcane, nearly 40 to 56 per cent of the additional irrigation water was used for sugarcane. Farmers preferred sugarcane because returns were very high per unit of land. However, sugarcane made a case of an uneconomical use of water when compared to foodgrains where returns per unit of water use were higher. Diversion of irrigation resources to foodgrains appeared to be both economically and sociologically justified on the grounds of equity.

Bowonder et al. (1987) showed that waterlogging and salinity have been increasing in many countries including India. The problem is critical because land lost is productive with irrigation facilities.

Pathak (1983) and Joshi (1987) described the impact of mismanagement of surface irrigation on land degradation. The direct effects of degradation included development of soil salinity/alkalinity and water logging conditions, decline in productivity and a loss of acreage for crop production. The indirect effects are diseconomies on the normal soil. To overcome this problem, provision of sub-surface drainage, conjunctive use of surface and groundwater, canal lining, on farm water management and organizational change are highly essential.

## 2.4 Need for Effective Improvements in Irrigation Techniques

Sengupta (1985) stated that traditional systems of irrigation evolved through several millennia had not only great variety, efficiency and variability, but were more in harmony with natural environment and were perfected over time. The modern methods of irrigation need time for perfection. Wherever modern irrigation developed as continuation of traditional techniques, they obtained noticeable success and where new method was introduced without paying attention to the local existing system, the new projects brought many undesirable effects.

Dutta (1987) described a role of groundwater in agricultural development in India and mentioned that the central government has launched a number of schemes for promoting groundwater development e.g. (i) Scheme for strengthening of groundwater and surface water organisations in the States, and (ii) Sprinkler/Drip system/ Hydroms water turbins and man and animal operated pumps. Centrally sponsored scheme was introduced in 1982-83 to encourage use of non-conventional devices for irrigation purposes, such as solar pumps, windmills, sprinkler/drip irrigation system hydroms, water turbins, etc.

Patil (1988) and Rangarajan (1992) stated that water is becoming scarce resource. The water table is

going down in many parts of the country. Efficient use of available water has, therefore, become important and it is in this context that the drip irrigation has an important role to play. Controlled supply of water can check the problem of salinity and soil degradation due to waterlogging which has become a common feature in the command area of many large irrigation projects. Drip irrigation is in favour of cash crops.

## 2.5 Water Requirement of Sugarcane

Some of the research workers have made work on water requirement of sugarcane. Zende (1972) mentioned that the optimum water requirement was 95 acre inches for Pundia and 120 acre inches for POJ 2878 varieties. It was concluded that for N dose of 150 lb/acre, 95 acre inches would be minimum and 120 acre inches would be optimum. Subsequent research work with Co 419, Co 740 varieties revealed that 115 acre inches was optimum water requirement for Adsali sugarcane under different soil types of Maharashtra.

Remdial (1974) studied some soil/plant moisture relationship for sugarcane on plots where irrigation is applied at 80, 120 or 160 gal/min. Moisture content was read at 10 cm intervals from 20 cm to 150 cm depth before and after each irrigation. Irrigation is recommended when $3/4^{th}$ of available moisture has evapotranspired. So

at sandy loam soils, irrigation should be applied on 14 to 18 day cycle.

In a book "Sugarcane Research at Padegaon" (MPKV), it has been described that water requirement of sugarcane is 290 hectare cm in 34-36 irrigation turns for a period of 12 months. The 7.5 ha-cm water per irrigation interval gives better efficiency and irrigation interval of 10 days at early growth phase, and 15-20 days in flowering, maturity stage gives good results. It is also observed that maximum yield of cane was obtained when ratoon is irrigated at 25 per cent deplition of soil moisture. The experiment at Basmatnagar revealed that the highest cane yield was obtained when irrigation is applied at 150 mm cumulative evaporation which was on par with 75 mm CE and superior to 300 mm CE, for suru sugarcane, irrigation at 1.0 IW/CPE ratio (10 ha-cm) depth needs to be maintained to get good results.

Sandhu (1981) described that requirement of water to sugarcane at different stages are different. Irrigation interval at 20 days from April onwards was more suitable. Mid-October to November was found to be a critical period of irrigation. Pre-harvest irrigation given at 0 and 32 days before harvest resulted in increase in yield and sugar production per acre.

Pawar et al. (1983) conducted an experiment on

layout, earthing-up and scheduling of irrigation for Adsali sugarcane at M.P.K.V., Rahuri and revealed that planting single eye bud cane in ridges and furrows showed better performance. Earthing-up gave more yield. Scheduling of irrigation at 75 mm CPE throughout the growing period with 270 cm total depth of irrigation water applied in 29 irrigations gave maximum yield with field WUE of 456.45 kg/ha-cm.

Pawar and Bhosale (1983) studied pre-monsoon irrigation requirements of sugarcane (CO 740) under Dapoli conditions and described that both irrigation interval based on cumulative pan evaporation and depths of irrigation water had effect on yield of sugarcane, however, brix, sucrose, purity of juice did not vary much. During pre-monsoon period, January planted sugarcane should be irrigated either after every 50 mm @ 5 ha-cm of water per irrigation or after every 70 mm CPE @ 7.5 ha-cm of water per irrigation.

Singh et al. (1984) studied irrigation requirement of sugarcane under Tarai conditions in Uttar Pradesh and revealed that close row spacing (60 cm) and irrigation at 45 and 75 days after planting gave the highest cane yields (72.9 to 79.3 t/ha) compared with 54.3 to 60.9 t/ha at 90 cm row spacing and irrigation at 75 days after planting.

Yadava (1991) indicated that water requirement of

sugarcane ranges between 1400 to 2500 mm being the lowest in Bihar and the highest in Maharashtra. In Karnataka, 2400 mm water found to be optimum. In Uttar Pradesh at Shahajahanpur, 1500 to 1600 mm water was required to raise crop, while at Barabanki, optimum yields were obtained when 1800 mm water was supplied to sugarcane. In Andhra Pradesh, 1600 to 1700 mm water is required. It is also observed that 20 irrigations at an interval of 12 days are required in Andhra Pradesh, while 36 irrigations are required in Maharashtra. In general, number of irrigations required in North India is less than that in South India.

## 2.6 Relative Efficiency in Drip Irrigation

As drip irrigation technology is recently introduced in our country, farmers are not much aware of it. So also a very few research studies have been carried out on this technology.

Sivanappan (1977) compared the drip irrigation with conventional surface irrigation and showed that farmen can save up to 80 per cent water. Pipes were proved with 1 mm holes protected by sleeves.

Yadava (1991) reported the results of an experiment conducted at Vasantdada Sugar Institute, Pune in 1989. In the experiment, surface and sub-surface drip with daily and alternate day irrigation and paired row planting were compared with conventional planting and furrow method of irrigation. Water saving in the case of surface drip in paired method of planting with daily and alternate day

irrigation treatment was 56.4 per cent, while it was 50.5 per cent in surface drip with paired method of planting and daily irrigation. Water saving in surface drip was minimum at 12.87 per cent.

Gutal et al. (1990) conducted an experiment on effects of drip irrigation systems (biwall, non-pressure compensating emitters or microtubes) and planting in pits with two drippers/pit on growth of sugarcane. Irrigation was scheduled on the basis of daily pan evaporation and crop growth stage. They found that the sugarcane yields were the lowest from the pit planting system (105 t/ha) with yields from other systems ranging from 120 to 134 t/ha. The pit planting system showed the highest water use efficiency and was 70 per cent more efficient than flood irrigation.

Aziz (1971) compared trickle method with surface method. The results showed that an average increase in yield over surface method was 11.4 and 16.0 per cent, while using drip for cabbage and melon, respectively. It was also observed that water saving was in order of 43.0, 47.0, 64.0 per cent with trickle irrigation to cabbage, potato, watermelon, respectively.

Gete (1993) observed 60 per cent water saving due to drip irrigation in sugarcane. The production of sugarcane increased from 20 to 25 per cent because of this

technology. Besides, there was saving of fertilizers up to 30 to 40 per cent.

According to Shinde (1982), 80 per cent available water in India is used for sugarcane. For cultivation of one acre of sugarcane requirement of water is 120 to 140 acre inches. However, farmers use about 250 acre inches of water per acre. It results in misutilization of water. The use of drip system can save 50 per cent of water compared to usedof traditional system.

Shan et al. (1977) conducted trials with 3 forms of drip irrigation and found that all the forms gave higher cane and sugar yields than did the surface irrigation. The best results were given with one drip tube along every sugarcane row which is slightly better than having one tube in the narrower inter-row of cane growth at alternate 0.97 and 2.26 meter spacing (as against 1.62 meter spacing for all the trials).

Chapman (1980) studied the sub-surface irrigation for Australian sugar industry for comparing the cane sugar yields with different irrigation systems. Drip irrigation scheduling based on class-A pan factor of 0.8 was satisfactory when the full canopy had developed. Cane growth differed little between daily and twice weekly schedules.

Godoy et al. (1985) indicated that the most efficient drip system for sugarcane is the biwall system

consisting of 3 main sections viz., (A) Hardware with media filter, ventury type pump, and pressure and flow meters, (B) Main and sub-main piping and (C) Biwall drip tubing. Sugarcane yield per hectare of variety PR 641-791 was 123 t/ha in 1984 and 134 t/ha in 1985. The trial carried out at Venezuella with underground drip irrigation in sugarcane indicated that the improved control of amount of water applied reduces losses from evaporation, and results into more efficient use of nutrients supplied through irrigation directly to roots.

Kale (1991) and Sivanappan et al. (1983) conducted separate studies in Kopargaon area of Maharashtra and Coimbatore area of Tamil Nadu, respectively, and found that drip irrigation results into higher productivity of sugarcane with reduced amount of irrigation.

Mane and Magar (1983) studied sugarcane response and water economy by adoption of drip irrigation technology on the basis of experiment at M.P.K.V., Rahuri. There was saving of water by 30 per cent and increase in yield by 20 per cent with drip method as compared to furrow method. Drip irrigation gave more yield than traditional system. The water use efficiency was double by drip method (902 kg/ha-cm) than traditional method (529 kg/ha-cm).

Anonymous (1986) studied with adsali sugarcane at Rahuri and indicated that drip method resulted in yield

increase of 19.9 per cent with water saving of 29.5 per cent over furrow with earthing up, while in suru sugarcane at Rahuri, the yield increased with drip was marginal (5.3 per cent with daily drip and 5.7 per cent with alternate day drip) with a water saving of 59.7 per cent.

Dhotrey and Mane (1988) analysed the data on adoption of portable lateral drip system of irrigation for sugarcane (Var. CO 7219). The single eye bud and paired row planting method was used to suit the layout for drip system. The analysis of yield showed that alternate day application of water through drip method was superior over furrow method. On an average, there was 6.21 per cent increase in cane yield by drip method with 62.04 per cent saving in water. The highest water use efficiency (21.46 q/ha-cm) was obtained in alternate day drip irrigation.

Shih (1988) compared difference in sugarcane evapotranspiration, sugarcane yield, soil moisture content between drip irrigation and sub-irrigation using 4 lysimeters. The results showed that the soil moisture content in the profile with sub-irrigation system was much greater than with drip irrigation system. About 95 kg and 109 kg of water was required to produce 1 kg of cane yield for drip irrigation and sub-irrigation, respectively.

On the basis of experimental results of drip irrigation and furrow irrigation methods in sugarcane production

on the research farms at M.P.K.V., Rahuri and T.N.A.U., Coimbatore, Sivanappan (1989) reported that drip irrigation method contributes to 50 to 60 per cent saving in irrigation water and 29 per cent increase in sugarcane output compared to furrow irrigation method.

Patil (1989) reported that drip irrigation method proved to be quite useful for sugarcane cultivation on salty soils as it allows 58 per cent water saving and 15 per cent increase in yield as compared to the traditional furrow method.

After studying the effect of biwall drip irrigation method on yield of suru sugarcane at Sugarcane Research Station, Padegaon, Jadhav et al. (1993) observed the saving of irrigation water to the extent of 36.89 per cent in biwall and 22 per cent in drip irrigation method than normal method of irrigation. There was an increase in sugarcane yield up to 7 per cent in drip method and 3.44 per cent in biwall method of irrigation than traditional method. The water use efficiency also increased in biwall and drip method than in ridges and furrows.

Sivanappan (1992) reported that biwall irrigation is very well suited for all the close growing crops like sugarcane, cotton, vegetables, grapes, onion, etc. This advanced technology not only saves about 50 to 70 per cent water, but also increases yield by 50 to 100 per cent.

Magar (1985) conducted an experiment on drip irrigation adaptability for sugarcane, water saving and reduction in cost and reported that the quantity of water up to 65 per cent could be saved by using drip method along with increase in yield (10 to 15 per cent) and sugar recovery (0.5 to 1.0 per cent). The cost of drip system was reduced by changing crop geometry and cost was reduced by 50 per cent by selecting pair planting at 60-140 X 30 cm spacing.

Deshmukh et al. (1988) compared both surface drip and sub-surface drip irrigation methods with daily and alternate day irrigation and paired row method of planting for sugarcane Co 7219 with conventional planting and furrow method of irrigation (control) and reported the water saving to the extent of 50 to 55 per cent, higher yield, better C.C.S. percentage, 2.7 times more water use efficiency for both surface and sub-surface method and paired row planting than the control. Among the treatments, the surface drip with daily irrigation and paired row planting treatment recorded the highest unit weight of cane and the highest yield per kg.

Combres et al. (1989) reported that daily underground drip irrigation was better than weekly overhead sprinkler irrigation in a study carried out on plant cane and first ratoon crops on vertisols in Guadeloupe. Drip irrigation resulted in 6.6 t sugar per hectare more than the

rainfed control and 2.9 t/ha more than sprinkler irrigation. Deep clay soils depressed yields of drip irrigated cane, but yields were still similar to those of sprinkler irrigated sugarcane.

Mannai and Sallam (1972), Deshmukh (1989), Bryan (1976), Orth (1979), Hall (1982), Padmakumari and Sivanappan (1979) have conducted studies in order to examine the efficiency of drip method in coastal region, Gustafsan (1971), Bresler (1977), Paliwal (1986) conducted studies to examine the effect of drip irrigation on crop yield and soil salinity hazards. The studies were conducted to examine the efficiency of drip irrigation on the crop yields and water saving by different researchers in respect of different crops. Goldberg and Schumielli (1969) and Phirke (1992) conducted studies for vegetable crops and Bangal et al. (1987), Kulkarni (1988), Kulkarni and Suryawanshi (1988) conducted studies in respect of pomegranate. Roth et al. (1978), Pawade (1989) and Datten and Haminson (1971) conducted studies for citrus crops, Londhe and Kalbande (1980) and Singh and Ranvir (1989) conducted studies on tomatoes, Singh et al. (1981), Singh (1973) and Singh and Singh (1978) conducted studies for cucumber, bottlegourd and long gourd, respectively. Patil (1989) conducted a study for banana, Baldota and Bhatane (1983), Sammis and Hanson (1980) conducted studies for

brinjal and spring potatoes and lettuce; and Shanmugham et al. (1976), Sivanappan et al. (1980), Clerk (1979) and Nemon et al. (1987) conducted studies for cotton, cotton and chilli and maize crops, respectively. All these studies revealed that the drip irrigation method helped farmers in increasing the crop yields of all the crops studied and water saving and drip irrigation method was observed to be superior over conventional methods, sub-surface irrigation methods and sprinkler irrigation method as well.

## 2.7 Problems of Drip Irrigation

Several researchers have shown that the drip irrigation technology is more advantageous because of many reasons. This technology is, however, not totally free from any problems. Quite a few research workers have tried to find out limitations/problems associated with drip irrigation technology at the field level.

Gibson (1978) carried out research on underground drip irrigation system in Hawai. He observed that in shallow drip irrigation system, tubes are being destroyed during harvesting. He recommended the use of chemicals to control ants which attacked the plastic tubes. He emphasised need for sub-surface irrigation by means of tubes burried at a greater depth to provide water to ratoon crops as well as plant cane.

Bucks et al. (1979) worked on water quality and preventive maintenance in trickle irrigation. The most serious problem in trickle irrigation was clogging of emitters. The preventive maintenance included water filtration, chemical treatment, pipeline flushing and field inspection.

Wayse and Kulkarni (1987) made a survey to identify problems of drip irrigation system adopted by grape growers in Sangli district. They reported the cracking of flexible pipes and uneven distribution of water at the field level.

# Methodology

# 3. METHODOLOGY

For any research study, the researcher has to adopt appropriate research methodology in arriving at meaningful conclusions from the study. In effect, research methodology is considered as a foundation of every scientific study. It is usually thought better to discuss the details of research methodology before presenting results of the study so that readers can understand the conclusions drawn from such study in their right perspective. In view of this, the present Chapter discusses in detail the research methodology adopted for the study. Moreover, it deals with the aspects like sources of data, the analytical procedure adopted for arriving at meaningful results for accomplishing requirements of the objectives of the study and various concepts underlying it.

## 3.1 Data Requirement and Sources of Data

The data requirement of the study included the farm level information regarding details of all cultivation practices of sugarcane by traditional method before drip irrigation and by biwall drip method after drip irrigation. It involved the aspects such as total labour and other inputs required for operations from preparatory tillage to harvesting of sugarcane, cost of production, total production and value of output of sugarcane before and after drip irrigation. This information was obtained from the sample

cultivators who are members of the cooperative lift irrigation scheme/biwall drip irrigation unit.

Another type of data required for the study included the information on investment costs and operating costs, and total revenue from irrigation charges of both cooperative lift irrigation scheme and the biwall drip irrigation unit. These data have been collected from the official records of the concerned cooperative lift irrigation scheme/ biwall drip irrigation unit.

## 3.2 Selection of Study Area

The present study was carried out in Sangli District. Ankalkhop village in Tasgaon tahsil in Sangli district was selected purposively for the study. A large number of lift irrigation units have been installed on Krishna, Yerala and Warana rivers on cooperative as well as private basis by the farmers. Additionally, efforts have been made by the sugar factories in the area to support installation of lift irrigation schemes as the regular activity to facilitate increased sugarcane production in the area of their jurisdiction. A beginning has been made in Ankalkhop village to install drip irrigation unit on one of the existing cooperative lift irrigation schemes in the village with the technical and financial support from the Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli. The Vasant Cooperative Lift Irrigation Scheme being the first unit of its kind in

the area, it was decided to select the unit purposively for detailed study. The unit has been used to irrigate sugarcane crop with biwall drip irrigation technology. It was, therefore, possible to find out the economic efficiency of biwall drip irrigation in sugarcane production in the command of the cooperative lift irrigation project.

## 3.3 The Sample Design

The study was based on primary data relating to various aspects of the use of biwall drip irrigation method in sugarcane production on the farms in the command of the cooperative lift irrigation project in Sangli district. For this purpose, the Vasant Cooperative Lift Irrigation Scheme which has installed biwall drip irrigation unit was selected purposively with the understanding that the farmers in its command were well conversed with biwall drip irrigation technology. Furthermore, a list of sugarcane growers in the command of the cooperative lift irrigation scheme was obtained along with the productivity levels (i.e. per hectare yield) of sugarcane with biwall irrigation technology. Subsequently, the farmers in the list were rearranged in the ascending order of sugarcane productivity of each farmer and the same was divided in 3 size groups viz., low, medium and high sugarcane productivity groups of farms depending upon yield of sugarcane as 75 to 100 tonnes, 101 to 125 tonnes and 126

tonnes and above per hectare, respectively. Finally, a sample of 30 sugarcane farms was selected randomly from each of the 3 size groups, thus making the total sample of 90 farms for the study.

## 3.4 Design of Schedule

The comprehensive sets of schedules/questionnaire were prepared separately for lift irrigation scheme/ biwall drip irrigation project and the sugarcane cultivators keeping in view the data requirements of the objectives of the study. A copy of each of the questionnaire used is given in Appendix-I.

## 3.5 Collection of the Data

The information on various aspects of sugarcane production with and without biwall drip irrigation technology was obtained from the sample farms by survey method through personal interview with the help of a questionnaire specially designed for the purpose. Similarly, detailed information on fixed investment and operating costs of biwall drip irrigation unit and the cooperative lift irrigation Scheme was obtained through personal interview and from the records available with the office of the concerned project. The reliable information was saught for by establishing personal rapport with the farmers and the office bearers of the cooperative lift irrigation scheme

and making the objectives of the study clear to them. The information collected pertains to the reference year 1987-88 and 1989-90.

## 3.6 Analysis of the Data

The data thus collected were compiled and analysed statistically in order to obtain estimates of additional costs and additional returns of biwall drip irrigation technology in sugarcane production both at the farm level and cooperative lift irrigation project level. The relative efficiency of biwall drip irrigation and traditional surface irrigation methods was studied through benefit-cost analysis, and estimated rate of return.

### 3.6.1 Comparative economics of the traditional irrigation and biwall drip irrigation methods

The comparative economics of the traditional irrigation method and biwall drip irrigation method in the command of the lift irrigation scheme was studied by way of comparing costs and returns structures of individual methods with each other through 'with' and 'without' approach. Also, additional costs and additional returns on account of biwall drip irrigation technology in sugarcane production were estimated at the farm level and cooperative lift irrigation project level as well.

3.6.1.1 Costs and returns structures of cooperative lift irrigation scheme with and without biwall drip irrigation technology

While working out the economics of traditional irrigation method and biwall drip irrigation method in the command of the lift irrigation scheme, all the costs were classified under two main categories viz. (1) Working cost or variable cost, and (2) Fixed cost or investment cost.

The working cost or variable cost is that cost which varies directly with the level of production. The variable cost includes the following items :

(1) Salaries and wages,
(2) Electricity and water charges,
(3) Repair and maintenance charges,
(4) Travelling expenses,
(5) Inspection and audit fees,
(6) Advertising expenses,
(7) Ceremonial expenses,
(8) Stationery and postage, and
(9) Other miscellaneous costs.

Fixed cost is that cost which does not vary with the level of production. Fixed cost includes the following items :

(1) Investment cost of lift irrigation scheme and biwall drip irrigation project,
(2) Interest on capital,
(3) Depreciation,
(4) Rent and taxes, and
(5) Insurance.

The costs on account of above items were available from the audited accounts statements of the scheme. The information on annual returns accrued to the scheme in the form of irrigation charges was obtained from the office records of the scheme.

3.6.1.2 Costs and returns structure of sugarcane production with and without drip irrigation technology

The total cost of production of sugarcane both under surface irrigation and biwall drip irrigation methods included the costs on account of items such as (1) Hired human labour, (2) Total bullock labour, (3) Seed material, (4) Manures, (5) Fertilizers, (6) Insecticides, (7) Irrigation charges, (8) Land revenue and taxes, (9) Depreciation, (10) Transport, (11) Interest on working capital, (12) Rental value of land, (13) Interest on fixed capital, and (14) Imputed value of family labour. The procedure followed for estimation and allocation of costs is explained in Appendix-II.

The estimates of returns, additional returns from biwall drip irrigation, net returns over working cost, net returns over total cost were obtained on per hectare basis for sample cultivators and net returns over working costs were also calculated for lift irrigation scheme and biwall drip irrigation unit.

### 3.6.2 Benefit-cost analysis

The relative efficiency of biwall drip irrigation and traditional surface irrigation methods was studied through benefit-cost analysis.

The benefit-cost ratio of biwall drip irrigation system was obtained by using formula :

$$\text{Benefit-cost ratio} = \frac{\text{Net additional annual benefits}}{\text{Interest on fixed capital} + \text{Annual working cost} + \text{Annual depreciation}}$$

### 3.6.3 The rate of return of biwall drip irrigation system :

The rate of return of biwall drip irrigation system was obtained by using the formula :

$$i = \frac{B - C - K/n}{K} \times 100$$

where,

i = Rate of return in per cent,

B = Total annual benefits,

C = Annual operating cost

K = Gross fixed capital investment,

n = Life period in years.

# General information of the study area and sample farms

# 4. GENERAL INFORMATION OF THE STUDY AREA AND SAMPLE FARMS

Agricultural production and returns mainly depend on a variety of climatic and geographical factors such as temperature, rainfall, soil types, river system, humidity, topography, etc., which vary from one place to another. These are the basic factors to determine the nature of farming and level of returns therefrom. While carrying out any research, it is necessary to study geographic and agro-economic features of the area to better understand study results in their right perspective. In the light of these considerations, efforts have been made in this Chapter to discuss in brief some of the important features of the study area, lift irrigation scheme and biwall drip irrigation unit under study.

## 4.1 Physical and Demographical Features of Sangli District and Tasgaon Tahsil

### 4.1.1 Location and boundaries

Sangli district lies on the West of Deccan Plateau between 16°45' and 17°33' North latitudes and 73°42 and 75°40' East longitudes. The district is to the extreme south-east corner of Maharashtra State and is close to the border of Karnataka State. The district is surrounded by Bijapur district of Karnataka State in the east, Kolhapur and Belgaum districts in the south, Ratnagiri district in the west, Satara district in the north, and Solapur district towards the north-east.

The maximum east-west length of the district measures about 200 km and north-south about 88 km. The total geographical area of the district is 8601.5 sq km divided in 8 tahsils. The population of Sangli district according to 1991 Census is 2197977. The proportions of the area and population of Sangli district to that of whole Maharashtra are 2.79 and 2.78 per cent, respectively.

Tasgaon tahsil is located at the centre of Sangli district (Fig. 1). The total area of the tahsil is 1111.5 sq km and its population is 361200 according to 1991 census. The tahsil is surrounded by Walwa tahsil towards west, Khanapur tahsil towards north-east, Kavathemahankal tahsil on its east and Miraj tahsil towards south.

### 4.1.2 Topography and soils

The central portion of Sangli district comprising of Walwa tahsil and western parts of Tasgaon and Miraj tahsils is formed by plains. The western part of the district consists of high hills which form the branches of Sahyadri running towards east from the northern side of the district. Another range of hills starting from Mahadeo hills runs towards south and covers northern portion of the eastern part of the district. Naturally, the district is sloping from north to south.

The soils in the district are of varied texture and

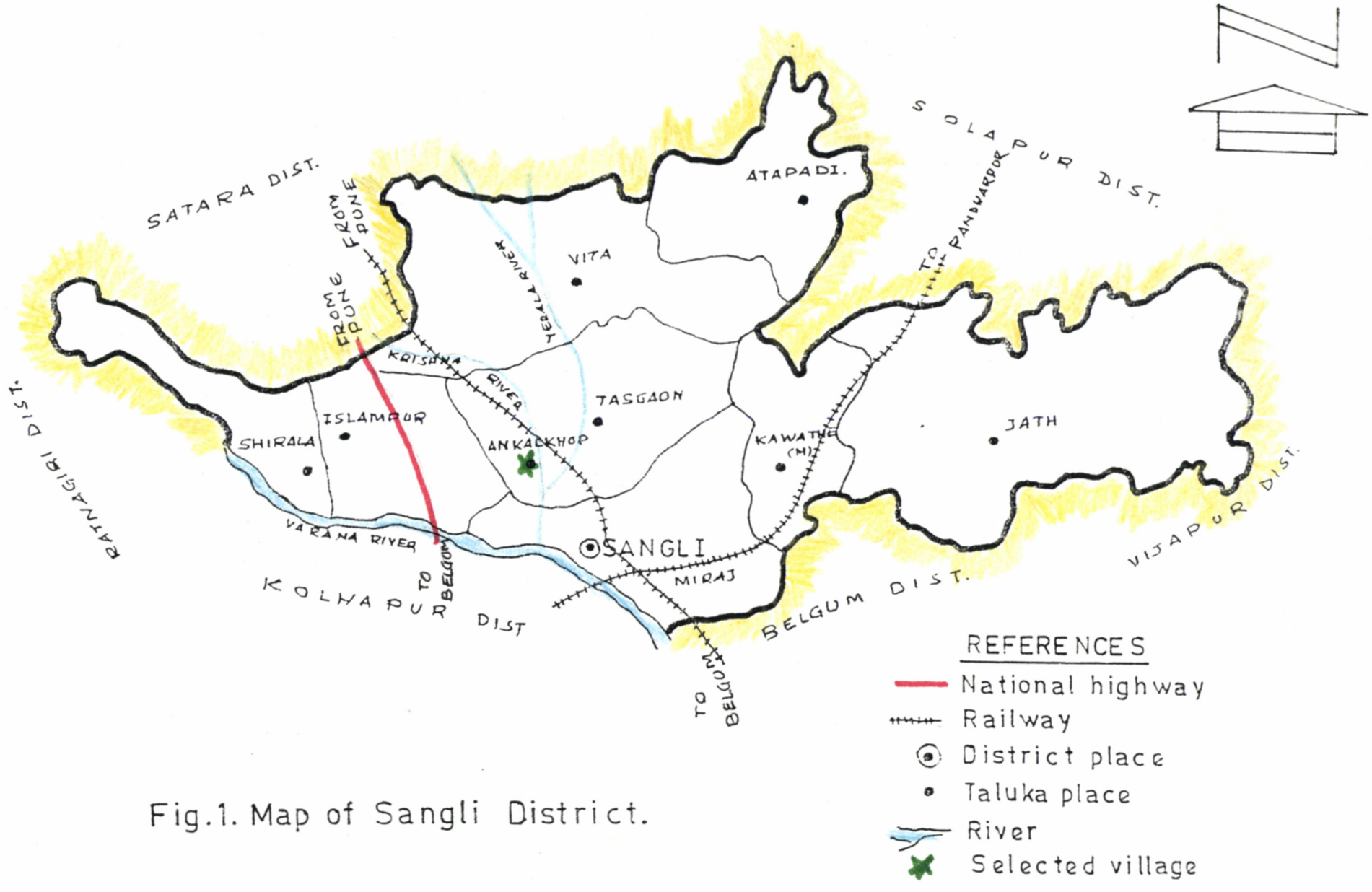



Fig.1. Map of Sangli District.

structure. They vary from deep black in the river valleys of Krishna, Warana and Yerala to shallow murmad red or grey in the hilly areas of eastern part of Tasgaon and Miraj tahsils. In Walwa tahsil, soils are heavy deep black. The eastern zone consisting of Jath, Atpadi, Khanapur and Kavathemahankal tahsils is having hilly tract with poor grey laterite soils.

On the basis of topography, Tasgaon tahsil is divided in 3 zones viz., (i) fertile zone of banks of Krishna river, (ii) hilly tract of light soils, and (iii) eastern zone having light soils. The soils in the northern and eastern parts are hard and less fertile. This part is low rainfall area and known as scarcity tract of the tahsil. In the southern and western parts, the soils are generally black.

### 4.1.3 Rivers

Krishna and Warana are the principal rivers of Sangli district. Also Morna, Yerala, Manganga, Agrani and Bor are flowing through this district. Krishna river enters into Sangli district from Satara district and flows through Walwa, Tasgaon and Miraj tahsils.

### 4.1.4 Population

The population of Sangli district according to 1991 Census is 2197977 persons out of which 1080100 are females.

The sex ratio per 1000 males is 967. The density of population works out to 256 persons per sq km. The population of Tasgaon tahsil is 361200 persons according to 1991 Census out of which 184800 are males and 176400 are females.

## 4.2 Climate and Rainfall

There are three distinct seasons viz., rainy season, winter season and summer season in a year during the months of June to September, October to January and February to May, respectively. All the three seasons show a considerable uniformity within themselves in regard to temperature. They have local variations in temperature in the district. In western region, the climate is warm and healthy in summer but becomes chilly in rainy season. In central region, there is considerable heat during summer months and during winter months, the days are warm and nights are cool. The eastern region is having much high temperature than central and western regions during all the months.

The normal rainfall of Sangli district is 625 mm. There are wide variations in the average rainfall and number of rainy days within different tahsils. The major rainfall is received in July, August and September in all the tahsils.

The climate of Tasgaon tahsil is dry and vigorous, good for health throughout the year. In the tahsil, cool

climate is observed in hot weather, but it becomes chilly in rainy season. The average temperature of this tahsil is 24.7 °C.

## 4.3 Land Use and Cropping Patterns of Sangli District and Tasgaon Tahsil

### 4.3.1 Land use pattern

The land utilization pattern of Sangli district and Tasgaon tahsil for the year 1987-88 is given in Table 1.

Table 1. Land use pattern of Sangli district and Tasgaon tahsil in the year 1987-88

(Area in ha)

| Particulars | Sangli district | Tasgaon tahsil |
|---|---|---|
| 1. Total geographical area | 864015 (100.00) | 111151 (100.00) |
| 2. Area under forest | 47523 ( 5.50) | 4961 ( 4.46) |
| 3. Land put to non-agricultural uses | 53678 ( 6.21) | 9014 ( 8.11) |
| 4. Other cultivated land excluding fallow land | | |
| a) Cultural waste | 32432 ( 3.75) | -- -- |
| b) Land under misc. trees, crops, etc., not included in area sown | 15480 ( 1.79) | 1190 ( 1.07) |
| c) Permanent pastures and other grazing land | 19084 ( 2.21) | 6804 ( 6.12) |
| 5. Fallow land | | |
| a) Current fallows | 50342 ( 5.83) | 4104 ( 3.69) |
| b) Other fallows | 49187 ( 5.69) | 3894 ( 3.50) |
| 6. Net area sown | 596289 ( 69.01) | 81184 ( 73.04) |
| 7. Gross cropped area | 645107 | 86899 |
| 8. Cropping intensity(%) | 108.18 | 107.03 |

(Figures in the parentheses are percentages to the total).

Source : Socio-economic Review and District Statistical Abstract of Sangli district for 1989-90.

The proportion of net sown area in the total geographical area is higher in Tasgaon tahsil as compared to Sangli district. But the cropping intensity for Sangli district as a whole is more than that of Tasgaon tahsil. There is one point that there is no culturable waste land in Tasgaon tahsil. The area under forest forms a little over 5 per cent of the total geographical area in the district.

4.3.2 Area irrigated by different sources

The information on area irrigated by different sources of irrigation in Sangli district and Tasgaon tahsil is presented in Table 2 for the year 1987-88.

Table 2. Area irrigated by types of sources in Sangli district and Tasgaon tahsil in the year 1987-88.

(Area in ha)

| Particulars | Area irrigated by | | | |
|---|---|---|---|---|
| | Wells | Surface and other | Net irrigated area | Gross irrigated area |
| 1. Sangli district | 46344 (58.36) | 33069 (41.64) | 79413 (100.00) | 110650 |
| 2. Tasgaon tahsil | 5540 (33.79) | 10857 (66.21) | 16397 (100.00) | 22067 |

(Figures in the parentheses are percentages to net irrigated area).

Source : Socio-economic Review and District Statistical Abstract of Sangli district for the year 1989-90.

It would be seen from the table that well irrigation is the principal source of irrigation in Sangli

district. In Tasgaon tahsil, however, surface and other irrigation methods are principal sources. The net irrigated area under well irrigation in the district was 58.36 per cent and in Tasgaon tahsil, it was 33.79 per cent. The net irrigated area under surface and other irrigation sources in Sangli district was 41.64 per cent, and in Tasgaon tahsil, it was 66.21 per cent. The gross irrigated area in Sangli district was 110650, and in Tasgaon tahsil, it was 22067 hectares.

4.3.3 Cropping pattern

The cropping pattern of Sangli district and Tasgaon tahsil in the year 1987-88 is indicated in Table 3.

Table 3. Cropping pattern of Sangli district and Tasgaon tahsil in the year 1987-88

(Area in ha)

| | Crop | Sangli district | Tasgaon tahsil |
|---|---|---|---|
| 1. | Paddy | 17303 (2.68) | 1062 (1.22) |
| 2. | Wheat | 17029 (2.64) | 2376 (2.73) |
| 3. | Jowar | 259604 (40.24) | 43820 (50.42) |
| 4. | Maize | 4332 (0.67) | 377 (0.43) |
| 5. | Other cereals | 481 (0.07) | 221 (0.25) |
| 6. | Total cereals | 421561 (65.35) | 50409 (58.00) |
| 7. | Gram | 12325 (1.91) | 2365 (2.72) |

Table 3 (Contd...)

| | Crop | Sangli district | Tasgaon tahsil |
|---|---|---|---|
| 8. | Tur | 14617 ( 2.27) | 4465 ( 5.14) |
| 9. | Other pulses | 42470 ( 6.58) | 3809 ( 4.38) |
| 10. | Total pulses | 71461 (11.08) | 10829 (12.46) |
| 11. | Total foodgrain crops | 493022 (76.42) | 61238 (70.47) |
| 12. | Sugarcane | 40759 ( 6.32) | 13171 (15.16) |
| 13. | Total condiments and spices | 7169 ( 1.11) | 949 ( 1.09) |
| 14. | Fruits | 2444 ( 0.38) | 702 ( 0.81) |
| 15. | Vegetables | 2275 ( 0.35) | 307 ( 0.35) |
| 16. | Total foodgrain crops | 545753 (84.60) | 76367 (87.88) |
| 17. | Fibre crops | 1511 ( 0.23) | 75 ( 0.09) |
| 18. | Groundnut | 45606 ( 7.07) | 9870 (11.36) |
| 19. | Other oilseed crops | 5708 ( 0.88). | 90 ( 0.10) |
| 20. | Total oilseed crops | 60309 ( 9.35) | 10175 (11.71) |
| 21. | Total drug and narcotics | 3774 ( 0.59) | 255 ( 0.29) |
| 22. | Total nonfoodgrain crops | 99354 (15.40) | 10532 (12.12) |
| 23. | Total gross cropped area | 645107 (100.00) | 86899 (100.00) |

(Figures in the parentheses are percentages to the gross cropped area).

Source : Socio-economic Review and District Statistical Abstract of Sangli district for 1989-90.

The cropping pattern of Sangli district and Tasgaon tahsil indicates that jowar, groundnut, wheat, gram, paddy and sugarcane are the important crops grown in the area. The proportion of foodgrain crops in the gross cropped area was 76.42 per cent in the district and 70.47 per cent in the tahsil. The proportion of gross cropped area under sugarcane was relatively higher in the tahsil (15.16 per cent) than in the district (6.32 per cent). The area share of groundnut was 11.36 per cent in the tahsil and it was 7.07 per cent in the district. Thus, sugarcane and groundnut together shared relatively higher proportion of gross cropped area in the tahsil than that of the district. The area under non-food crops was 15.40 per cent of the gross cropped area in the district and 12.12 per cent in the tahsil.

Furthermore, the details of area irrigated under different crops in Sangli district and Tasgaon tahsil in the year 1987-88 are presented in Table 4.

It would be seen from the table that the largest portion of the gross irrigated area was under sugarcane. It was as much as 36.85 per cent in the district and 59.69 per cent in the tahsil. The irrigated cereals accounted for 44.06 per cent of the gross irrigated area in the district and 28.79 per cent in the tahsil. The area share of pulses in the gross irrigated area of the district was 3.02 per cent, while it was 1.51 per cent for the tahsil. The area

Table 4. The area shares of different crops in the gross irrigated area in Sangli district and Tasgaon tahsil in the year 1987-88

(Area in ha)

| | Irrigated crops | Sangli district | Tasgaon tahsil |
|---|---|---|---|
| 1. | Paddy | 6972 (6.30) | 1057 (4.79) |
| 2. | Wheat | 14518 (13.12) | 2172 (9.84) |
| 3. | Jowar | 18155 (16.41) | 2770 (12.55) |
| 4. | Maize | 2779 (2.51) | 355 (1.61) |
| 5. | Other cereals | 67 (0.06) | - |
| 6. | Total cereals | 48756 (44.06) | 6354 (28.79) |
| 7. | Total pulses | 3340 (3.02) | 334 (1.51) |
| 8. | Sugarcane | 40769 (36.85) | 13171 (59.69) |
| 9. | Total condiments and spices | 6362 (5.75) | 927 (4.20) |
| 10. | Fruits | 2422 (2.19) | 640 (2.90) |
| 11. | Vegetables | 2102 (1.90) | 262 (1.19) |
| 12. | Total food crops | 104021 (94.00) | 21688 (98.28) |
| 13. | Total nonfood crops | 6629 ( 5.99) | 379 (1.72) |
| 14. | Gross irrigated area | 110650 (100.00) | 22067 (100.00) |

(Figures in the parentheses are percentages to the gross irrigated area).

Source : Socio-economic Review and District Statistical Abstract of Sangli District for 1989-90.

share of total nonfood crops in the gross irrigated area was higher in the district (5.99 per cent) than that of the tahsil (1.72 per cent).

## 4.4 General Information About the Selected Village-Ankalkhop

The village Ankalkhop is situated about 16 km away to the west of taluka headquarter Tasgaon and 33 km away from the district headquarter. The name of the village is derived from local God. The village is surrounded by Krishna river on both the sides, the north and the east. The nearest railway station is Bhilwadi which is 6.5 km away from this village.

The geographical area of this village is 1902.19 hectares. The population of the village is 11178 according to 1991 Census. The educational facilities in the village include primary schools, high-school and junior college. Weekly bazar provides marketing facilities to the villagers. The medical facilities are provided by private dispensaries and medical health centre of the government department. The health care facilities for animals are provided by the veterinary dispensary in the village. This village is having a separate Grampanchayat established in 1923 as well as multipurpose cooperative society which are commited themselves for the betterment of the villagers, in general, and agriculture, in

particular. The transport and communication facilities are well developed. There are different types of social organisations such as Youth Club and Mahila Mandal in the village. Other infrastructural facilities are being provided by fair price shops, hotels, Krishi Seva Kendras, Banks and various types of shops such as Kirana shops, Stationery shops, medical stores, engineering workshops, etc. The library facility is also available in the village. Cooperative lift irrigation schemes on Krishna river and pumping sets provide irrigation facilities. Farmers cultivate jowar, paddy and groundnut. With the assured supply of water, cultivators are more inclined to go for cultivation of cash crops, mainly sugarcane. They are also aware of using biwall drip irrigation technology for sugarcane. The people are cooperative and work hand in hand with each other for the betterment of the village.

## 4.5 General Information of the Lift Irrigation Scheme and Biwall Drip Irrigation Unit

It is important to know the physical features of the selected lift irrigation scheme and biwall drip irrigation unit. This type of knowledge would facilitate better understanding of the observations regarding capital investment, recurring costs, returns and other related aspects of the biwall drip irrigation unit.

4.5.1 The lift irrigation scheme

The lift irrigation scheme under study viz., Vasant Lift Irrigation Scheme was established in the year 1963 on cooperative basis by the farmer members under the dynamic leadership of late Dinkarbapu Patil and able guidance of late Vasantraodada Patil with the help of Shetkari Sahakari Sakhar Karkhana Ltd., Sangli. The scheme has been installed on the bank of Krishna river. The actual working of the scheme was started in 1965. This is a cooperative lift irrigation scheme fully financed by the sugar factory.

The command area of the scheme is 240 hectares. It has got the licence from the government for perennial water supply to 48 hectares of land and licence to irrigate 40 per cent area under kharif crops and 40 per cent area under rabi crops. The number of members is 235.

The scheme is jack-well type. A jack-well of 12 feet diameter and 63 feet deep is connected with intake well of 6 feet diameter and 10 feet deep in the river by 24 inches and 270 feet long intake pipe. The water is lifted through rising main of 24 inches diameter and 6400 feet length. A delivery chamber of the dimension of 6 feet diameter and 9.5 feet height is at the end of the rising main. Other distributories include different sizes of 21 cross cement pipe lines of the diameter of 12 inches

and 6 inches. The scheme has installed following types of pumps on jack-well : (i) 150 H.P. pump and pump set, and (ii) 110 H.P. and 55 H.P. stod bipump. The total water discharge of the pumps is 8 qusecs.

The total irrigated area during 1988-89 was 130 hectares of which sugarcane alone occupied the area of 63.2 hectares and rest of the area was shared by kharif and rabi crops and other perennial crops as well.

4.5.2 The biwall drip irrigation unit

The member farmers did not get required water quantities to irrigate different crops. This situation resulted into decline in crop yields and returns to the farmers. Also the income of the scheme was affected adversely. The board of directors of the sugar factory and the members of the lift irrigation scheme, therefore, decided to go for modern technology of irrigation. They decided unanimously to install biwall drip irrigation unit on the existing lift irrigation scheme. The proposal was supported by the sugar factory. The biwall drip irrigation set was installed on the scheme in 1989. Biwall drip irrigation is one of the types of the drip irrigation which is used for row crops. They adopted this new technology to irrigate 177.2 hectares of land out of 240 hectares of command area. The total investment cost to establish a huge modern technology in such a large area amounted to

Rs. 56.27 lakhs. For proper water management purpose, the scheme has divided the area in 30 groups and these 30 groups are distributed to 28 wells. These wells have been rented in from the member farmers and used as store-wells. The layout of the biwall drip irrigation unit is depicted in Fig. 2. The water is lifted by the scheme from river and stored in these wells. Thereafter, water is supplied to different irrigated areas with the help of biwall drip irrigation unit operated by electric pumps on these wells. The capacity of the electric motor ranges from 3 H.P. to 12.5 H.P. and the total capacity of all the 30 electric motors is 270.5 H.P. The following types of P.V.C. pipes are being used for the system.

| Type of PVC pipes | Length (Meters) |
|---|---|
| 50 mm | 9002 |
| 63 mm | 7968 |
| 75 mm | 4888 |
| 90 mm | 4256 |
| 110 mm | 8512 |
| 140 mm | 360 |
| 15 mm biwall | 684790 |
| Polytube | 139480 |

A 150 H.P. electric pump is operated on the jack-well of the scheme. Water lifted from the river firstly enters into main delivery chamber and then it goes to each

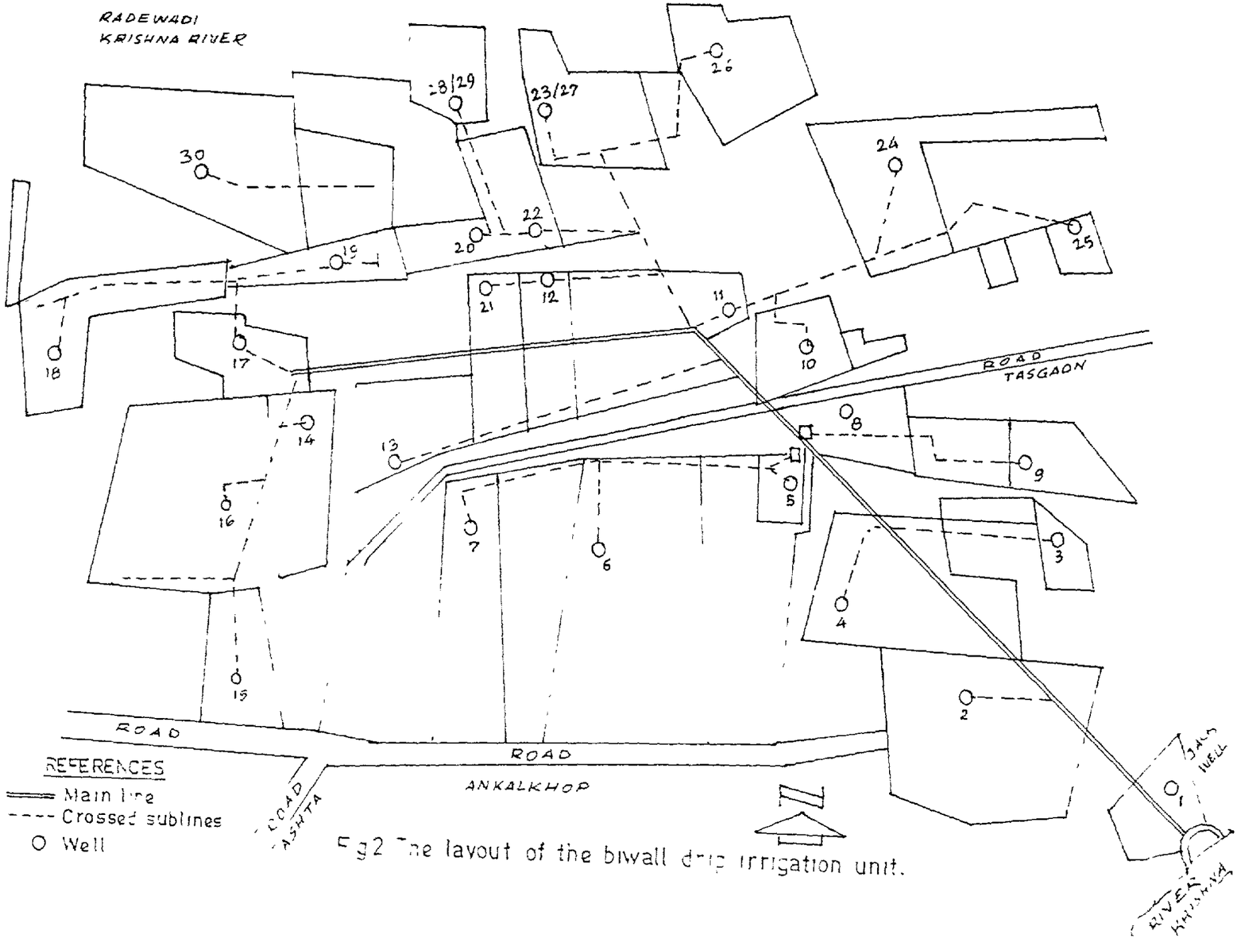



Fig 2 The layout of the bilwall drip irrigation unit.

well of the groups through cement pipes. On each well, a biwall drip irrigation unit is operating. Each biwall drip irrigation unit has different components viz., well, electric pump, bypass, valves, ventury valve, main valve, pressure guage, fertilizer tank, filter tank, back wash system, main line, submain, biwall-lateral, etc.

The water is lifted from well. Then it passes through various valves to bypass then to ventury valve and to filter tank. From the filter tank, it goes to main, submain, biwall lateral and to roots of crops. The pressure guage is placed on this unit. It indicates the pressure of water. Normally, it requires 1.75 to 2.0 kg pressure. A ventury section is provided for applying fertilizers through the water. A fertilizer tank is connected with the help of ventury in between ventury valves. The pressure required for the ventury is 1.5 to 2.0 kg. At the time of back wash, the water passes through well, pump, various valves, bypass to filter and out through backwash. At this time main valve is closed (Fig. 3).

The water application to different crops in different seasons are different. The water delivery system is operated with the help of employees of the lift irrigation scheme. For avoiding the problems of choking of biwall pipes, cutting of pipes by rats, and choking of filters, the management practices hydrochloric acid treatment and

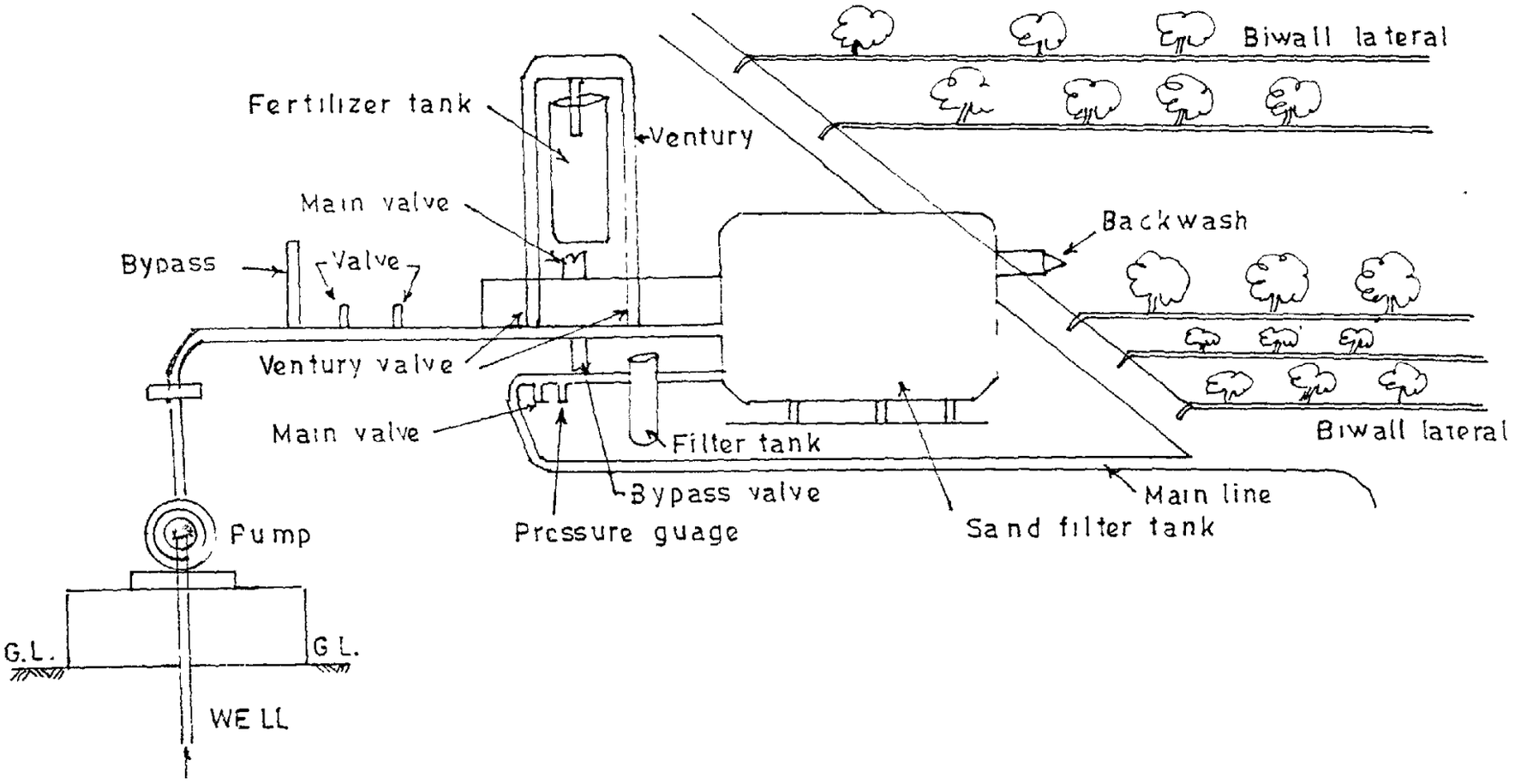



Fig. 3. Schematic diagram of the components of bi wall drip irrigation system.

bleaching powder treatment for each crop at the interval of 15 days. These treatments are given through water to remove mud, plants or other external things from the pipes and thus filters remain clean and water is distributed properly. Also urea is applied through water at the rate of 30 kg/month/hectare up to 7 months for sugarcane crop. The Sangli District Central Cooperative Bank has advanced medium term loan of Rs. 21.77 lakhs through the Ankalkhop Vikas Cooperative Society in the names of individual members. The Vasantdada Shetkari Sahakari Sakhar Karkhana has invested Rs. 15.00 lakhs for installation of this unit. The Government of Maharashtra has given a subsidy of Rs. 19.50 lakhs to this Unit.

For the cash crops like sugarcane and vegetables, some of the manufacturers have introduced a special tubing system known as biwall. Initially a single chambered tubing was introduced which consisted of a thin wall plastic tubing with small criticies. However, this type of tubing had a number of drawbacks. Because of very small orifices, a low operating pressure was essential to achieve the desired low application rate. This was not possible as small orifices tended to plug more easily and low operation pressures presented many design difficulties and constraints. To overcome these difficulties, a dual chambered tube with much improved hydraulic characteristics commonly known as

biwall tubing was introduced. The dual tube concept allows for longer orifices, higher operating pressures and lower application rate.

The Hardie biwall is patented extruded dual chamber micro irrigation tubing manufactured from a linear low density polyethylene. Holes are drilled by lacer beam at intervals of 30 cm along the tube to give even and equal amounts of water to plants over long lengths. Designed primarily for row crops, biwall is now manufactured in many different forms and has been used in a variety of crops. The tube may be placed on or below ground and can be installed mechanically combined with modern filteration technology and the ability to apply fertilizers and other treatments through the tubing to the plant. The biwall system embodies the best achievements of micro irrigation technology today.

### 4.5.3 Cropping pattern in the command of the lift irrigation scheme

The details of the cropping pattern in the command area of lift irrigation scheme during the years 1987-88 and 1989-90 i.e. before and after installation of biwall drip irrigation unit are given in Table 5.

It is observed from the table that most of the irrigation water was utilized for sugarcane (36.92 per cent). Sugarcane was the major perennial crop before

Table 5. Cropping pattern of lift irrigation scheme and biwall drip irrigation unit

| Season | Crops | Area under crops (ha) | Percentage |
|---|---|---|---|
| | A. Before biwall drip irrigation | | |
| 1. Kharif | 1. Hybrid jowar | 10 | 7.69 |
| | 2. Soybean | 10 | 7.69 |
| | 3. Groundnut | 2.8 | 2.15 |
| | 4. Paddy | 4 | 3.07 |
| 2. Rabi | 1. Wheat | 20 | 15.38 |
| | 2. Gram | 20 | 15.38 |
| 3. Summer | - | - | - |
| 4. Annual | - | - | - |
| 5. Perennial | 1. Sugarcane | 48 | 36.92 |
| | 2. Banana | 6.4 | 4.92 |
| | 3. Grapes | 3.6 | 2.76 |
| | 4. Betelvine | 3.2 | 2.46 |
| | 5. Roses | 2 | 1.53 |
| | Total | 130 | 100.00 |
| | B. After biwall drip irrigation | | |
| 1. Kharif | - | - | - |
| 2. Rabi | - | - | - |
| 3. Summer | - | - | - |
| 4. Annual | - | - | - |
| 5. Perennial | 1. Sugarcane | 148 | 83.52 |
| | 2. Grapes | 5.60 | 3.16 |
| | 3. Betelvine | 5.60 | 3.16 |
| | 4. Pomegranate | 4.80 | 2.71 |
| | 5. Ber | 0.80 | 0.45 |
| | 6. Banana | 12.00 | 6.77 |
| | 7. Fig | 0.40 | 0.23 |
| | Total | 177.20 | 100.00 |

installation of biwall drip irrigation unit. In kharif season, hybrid jowar and soybean contributed equal area shares. The area shares of wheat and gram also remained of the same magnitude. Among the perennial crops, the scheme allocated relatively more water to banana after sugarcane (4.92 per cent), while roses got the least (1.53 per cent) water share.

After installation of biwall drip irrigation unit, sugarcane was the major perennial crop in the command area with its area share of 83.52 per cent. It was followed by banana (6.77 per cent), grapes (3.16 per cent), betelvine (3.16 per cent) and pomogranate (2.71 per cent).

4.5.4 Management of the lift irrigation scheme and biwall drip irrigation unit.

The cooperative lift irrigation scheme/biwall drip irrigation unit was under the control of sugar factory. It was sponsored by the sugar factory. The management of the scheme/unit was vested with the special department created under the control of irrigation department of the sugar factory to supervise working of lift irrigation scheme/ biwall drip irrigation unit. It was in the form of two tier structure. Some management body was present at sugar factory level. Some management bodies were at scheme/unit level. At the factory level, technical staff was maintained, and at the scheme/unit level secretary, watermen and

operators were appointed. The overall incharge of the lift irrigation scheme/biwall drip irrigation unit was the chairman of the sugar factory. There was decentralization of the management which was possible only due to the mutual working of the lift irrigation scheme/biwall drip irrigation unit. This type of decentralization made it possible to render effective and prompt services. The working and financing of maintenance activity was limited and it mainly related to the collection of irrigation charges from the member cultivators.

In general, all the cultivators were growing sugarcane as a cash crop in the tract and the same was marketed to the sugar factory. The irrigation charges and other dues were collected from the cultivators by the sugar factory in proper way. Those beneficiaries who have cultivated sugarcane were paying irrigation charges to the secretary of the lift irrigation scheme/biwall drip irrigation unit.

## 4.6 Socio-Economic Aspects of the Selected Farm Families

This section is devoted to discuss in brief certain socio-economic aspects of the sample farms in the command of the cooperative lift irrigation scheme having biwall drip irrigation unit. The sample farms have been divided in three groups according to the productivity of

sugarcane as low, medium and high as indicated in Chapter-3. The social aspects relating to family size, its composition, educational level of family members and work force of the families and economic aspects relating to farm size, land use and crop patterns, capital investment, resource structure, etc. have been studied at two points in time i.e. before and after installation of biwall drip irrigation unit.

4.6.1 Size of family and education of sample farmers

Size of the family is the important factor affecting consumption needs and income earnings of the family. Education is another important factor influencing managerial ability, work efficiency, knowledge and technical knowhow of farming. The details about average size of family, its composition and education are given in Table 6.

At the overall level, the size of the family was 4.92 persons constituting 2.22 men, 2.03 women and 0.67 children. The size of family of the farms with low, medium, high sugarcane, productivity groups was 5.72, 5.11 and 3.94 persons, respectively. In all groups, the number of males was higher than women and children.

The level of education increased as the size of family decreased. This might be due to the better economic conditions of the farmers from the lower family size group, who could get more education. About 28.5 per cent, 11.55

Table 6. Family size and its composition of the sample farms

| Particulars | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|
| | Low | Medium | High | |
| 1. Family size | 5.72 (100.00) | 5.11 (100.00) | 3.94 (100.00) | 4.92 (100.00) |
| (a) Men | 2.46 (43.00) | 2.36 (46.18) | 1.83 (46.45) | 2.22 (45.12) |
| (b) Women | 2.23 (39.00) | 2.09 (40.90) | 1.79 (45.43) | 2.03 (41.26) |
| (c) Children | 1.03 (18.00) | 0.66 (12.92) | 0.32 (8.12) | 0.67 (13.62) |
| 2. Literates | 4.09 (71.50) | 4.52 (88.45) | 3.52 (89.34) | 4.04 (82.11) |
| (a) Men | 1.96 (34.27) | 2.23 (43.64) | 1.83 (46.45) | 2.01 (40.85) |
| (b) Women | 1.30 (22.72) | 1.76 (34.44) | 1.63 (41.37) | 1.56 (31.71) |
| (c) Children | 0.83 (14.51) | 0.53 (10.37) | 0.06 (1.52) | 0.47 (9.55) |
| 3. Illiterates | 1.63 (28.50) | 0.59 (11.55) | 0.42 (10.66) | 0.88 (17.89) |
| (a) Men | 0.50 (8.74) | 0.13 (2.54) | - | 0.21 (4.27) |
| (b) Women | 0.93 (16.26) | 0.33 (6.47) | 0.16 (4.06) | 0.47 (9.55) |
| (c) Children | 0.20 (3.50) | 0.13 (2.54) | 0.26 (6.60) | 0.20 (4.07) |
| 4. Total workers | 2.26 (39.51) | 2.16 (42.27) | 1.40 (35.53) | 1.94 (39.43) |
| 5. Total dependents | 3.46 (60.49) | 2.95 (57.73) | 2.54 (64.47) | 2.98 (60.57) |

(Figures in parentheses are percentages to total)

per cent and 10.66 per cent of the members were illiterate in the low, medium and high productivity groups, respectively. The literacy percentage was the lowest (1.52 per cent) in high productivity group, while it was the highest (14.51 per cent) in low productivity group. The total number of workers decreased in accordance with the increase in productivity of sugarcane.

### 4.6.2 Relationship between farm size and sugarcane productivity groups

The bivariate frequency distribution of sample farms is given in Table 7.according to size of farm and production level of sugarcane. In general, there was no specific relationship between the size of farm and productivity level of sugarcane. Moreover, the distribution of small farms according to productivity level of sugarcane was equal. A majority of the medium sized farms had low productivity level of sugarcane. In the case of the large sized farms, however, relatively a large number of farms had medium and high productivity levels of sugarcane. That means, the large sized farms could afford to spend relatively more on different inputs in order to realise high productivity of sugarcane as compared to the other size groups of farms.

Table 7. Bivariate frequency distribution of the sample farm families according to the size of farm and level of sugarcane productivity

| | Sugarcane productivity group | Farm size | | | Total |
|---|---|---|---|---|---|
| | | Small (Less than 1.20 ha) | Medium (1.21 to 2.20 ha) | Large (2.21 to 4.80 ha) | |
| 1. | Low | 14 | 12 | 4 | 30 |
| 2. | Medium | 13 | 8 | 9 | 30 |
| 3. | High | 13 | 8 | 9 | 30 |
| | Total | 40 | 28 | 22 | 90 |

4.6.3 Average land use pattern of sample cultivators

The average land use pattern of the sample farms selected under different size groups of sugarcane productivity is presented in Table 8 for the two time periods viz., before drip irrigation and after drip irrigation.

The average size of holding was relatively large in high sugarcane productivity group (1.94 ha) than the rest of two groups. About 94.50 to 96.50 per cent of the total area was cultivated among all the groups of sugarcane productivity of the sample farms before installation of drip irrigation. After drip irrigation, the proportions of cultivated area in the total area ranged between 92.50 to 96.50 per cent indicating thereby almost smaller change in the land use pattern on introduction of biwall drip irrigation technology. The total

irrigated area, however, increased in each group after drip irrigation. It was observed that the area under cultivation decreased slightly after drip irrigation in all the groups mainly because of diversion of some area for construction of buildings, roads, etc.

The proportion of net irrigated area in the net cultivated area was 64.87, 79.56 and 77.83 per cent in case of the farms belonging to the low, medium and high sugarcane productivity groups, respectively before drip irrigation. After drip irrigation, these proportions increased to 89.19, 96.68 and 93.29 per cent for the respective groups. Moreover, irrigated area was proportionately high in case of the higher sugarcane productivity groups. Before drip irrigation, the per farm gross cropped area was the highest in the medium sugarcane productivity group and the per farm gross irrigated area was the highest in the high sugarcane productivity group. After drip irrigation, however, the per farm gross cropped and gross irrigated area as well were the highest in the high sugarcane productivity group. It is worthwhile to note that because of wide coverage of the area under lift irrigation scheme biwall drip irrigation unit, the net area left unirrigated was very less i.e. 0.01 hectare per farm at the overall level.

Table 8. Average land use pattern of sample cultivators under different size groups of sugarcane productivity

(Area in ha)

| | Particulars | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|---|
| | | Low | Medium | High | |
| | | Before drip irrigation | | | |
| 1. | Total owned land | 1.48 (100.00) | 1.81 (100.00) | 1.94 (100.00) | 1.75 (100.00) |
| 2. | Area under buildings, roads, fallow land | 0.04 (2.70) | 0.06 (3.31) | 0.11 (5.67) | 0.08 (4.57) |
| 3. | Area under cultivation | 1.44 (97.30) | 1.75 (96.68) | 1.83 (94.32) | 1.67 (95.43) |
| | (a) Irrigated | 0.96 (64.87) | 1.44 (79.56) | 1.51 (77.83) | 1.30 (74.29) |
| | (b) Unirrigated | 0.48 (32.43) | 0.31 (17.12) | 0.32 (16.49) | 0.37 (21.14) |
| 4. | Gross cropped area | 1.52 | 2.02 | 1.90 | 1.81 |
| 5. | Gross irrigated area | 0.96 | 1.44 | 1.51 | 1.30 |
| 6. | Cropping intensity | 105.55 | 115.42 | 103.82 | 108.38 |
| 7. | Irrigation intensity | 100.00 | 100.00 | 100.00 | 100.00 |
| | | After drip irrigation | | | |
| 1. | Total owned land | 1.48 (100.00) | 1.81 (100.00) | 1.94 (100.00) | 1.75 (100.00) |
| 2. | Area under buildings, roads, fallow land | 0.11 (7.43) | 0.06 (3.31) | 0.13 (6.70) | 0.11 (6.29) |
| 3. | Area under cultivation | 1.37 (92.57) | 1.75 (96.68) | 1.81 (93.29) | 1.64 (93.71) |
| 4. | (a) Irrigated | 1.32 (89.19) | 1.75 (96.68) | 1.81 (93.29) | 1.63 (93.14) |
| | (b) Unirrigated | 0.05 (3.38) | - | - | 0.01 (0.57) |
| 4. | Gross cropped area | 1.37 | 1.78 | 1.82 | 1.66 |
| 5. | Gross irrigated area | 1.37 | 1.78 | 1.82 | 1.66 |
| 6. | Cropping intensity | 100.00 | 101.71 | 100.55 | 101.22 |
| 7. | Irrigation intensity | 103.79 | 101.71 | 100.55 | 101.84 |

(Figures in parentheses indicate percentages to total owned land).

### 4.6.4 Intensity of cropping and intensity of irrigation

The last rows of Table 8 indicate the cropping intensity and irrigation intensity on the sample farms belonging to different sugarcane productivity groups. It is observed from the data that the cropping intensity has decreased to the extent of 3 to 14 per cent after the introduction of biwall drip irrigation technology on the farms belonging to different sugarcane productivity groups. It is, however, interesting to note that the irrigation intensity has increased slightly on all the farms after introduction of biwall drip irrigation technology. This has happened mainly because of increased area allocation to sugarcane crop after drip irrigation. At the overall level, the cropping intensity was 108.38 per cent and irrigation intensity was 100.00 per cent before drip irrigation. On introduction of biwall drip irrigation, the cropping intensity decreased to 102.22 per cent and irrigation intensity increased to 101.84 per cent.

### 4.6.5 Cropping pattern on the sample farms

The average cropping pattern on the sample farms is given in Table 9 at two points of time i.e. before drip irrigation and after drip irrigation.

It can be seen from the data that before drip irrigation, maximum area was devoted to sugarcane and other crops

Table 9. Average cropping pattern of sample farms

(Area in ha)

| Crops | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|
| | Low | Medium | High | |
| | **Before drip irrigation** | | | |
| 1. Kharif jowar | 0.18 (11.84) | 0.03 (1.49) | 0.07 (3.68) | 0.10 (5.50) |
| 2. Soybean | 0.16 (10.53) | 0.26 (12.87) | 0.17 (8.95) | 0.20 (11.00) |
| 3. Groundnut | 0.01 (0.66) | 0.01 (0.50) | - | 0.008 (0.44) |
| 4. Rabi jowar | - | - | - | - |
| 5. Wheat | 0.15 (9.87) | 0.12 (5.94) | 0.10 (5.26) | 0.12 (6.60) |
| 6. Gram | 0.07 (4.61) | 0.15 (7.42) | 0.04 (2.11) | 0.08 (4.40) |
| 7. Sugarcane | 0.90 (59.21) | 1.45 (71.78) | 1.46 (76.84) | 1.27 (69.86) |
| 8. Grapes | 0.05 (3.28) | - | 0.06 (3.16) | 0.04 (2.20) |
| Total | 1.52 (100.00) | 2.02 (100.00) | 1.90 (100.00) | 1.818 (100.00) |
| | **After drip irrigation** | | | |
| 1. Kharif jowar | 0.09 (6.57) | 0.07 (3.93) | 0.04 (2.20) | 0.07 (4.22) |
| 2. Soybean | 0.13 (9.49) | 0.04 (2.25) | 0.09 (4.95) | 0.09 (5.42) |
| 3. Groundnut | - | - | - | - |
| 4. Rabi jowar | 0.01 (0.73) | 0.01 (0.56) | 0.03 (1.65) | 0.02 (1.20) |
| 5. Wheat | 0.11 (8.03) | 0.04 (2.25) | 0.08 (4.40) | 0.07 (4.22) |
| 6. Gram | 0.03 (2.79) | 0.04 (2.25) | 0.03 (1.65) | 0.03 (1.81) |
| 7. Sugarcane (Biwall) | 0.77 (56.20) | 1.05 (58.99) | 1.05 (57.69) | 0.96 (57.83) |
| 8. Sugarcane (Traditional) | 0.23 (16.79) | 0.53 (29.77) | 0.47 (25.82) | 0.41 (24.70) |
| 9. Grapes | - | - | 0.03 (1.64) | 0.01 (0.60) |
| Total | 1.37 (100.00) | 1.78 (100.00) | 1.82 (100.00) | 1.66 (100.00) |

(Figures in the parentheses are percentages to total cropped area).

occupied little area. After drip irrigation also maximum area was occupied by sugarcane crop for which biwall drip irrigation system was installed. Rest of the crops got smaller area share.

At the overall level, the area share of sugarcane was 69.86 per cent of the gross cropped area before drip irrigation. It, however, increased to 82.53 per cent after drip irrigation. Out of this total area, share of sugarcane in the gross cropped area, the area share of sugarcane with biwall drip irrigation technology was 57.83 per cent and that of the sugarcane with traditional irrigation method was 24.70 per cent. The area shares of kharif jowar, soybean, wheat, gram and grapes in the gross cropped area decreased almost by 1.25 to 5.50 per cent after introduction of biwall drip irrigation technology.

The type of changes in the cropping pattern resulting from the introduction of biwall drip irrigation technology was mostly of similar type among the farms belonging to different sugarcane productivity groups. The area share of the individual crops in the gross cropped area, however, varied within a narrow range among the farms of different sugarcane productivity groups.

### 4.6.6 Investment costs and sources of funds for biwall drip irrigation unit.

The details of per farm investment costs and sources of funds for biwall drip irrigation system are given in Table 10 for the individual sugarcane productivity groups.

Table 10. Average capital investment for biwall drip irrigation unit

(Rupees)

| Particulars | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|
| | Low | Medium | High | |
| 1. Total investment for drip irrigation set | 28750.54 (100.00) | 37190.31 (100.00) | 43327.51 (100.00) | 36422.79 (100.00) |
| 2. Owned capital | - | - | - | - |
| 3. Loan from : | | | | |
| a) Sangli District Central Cooperative Bank through Ankalkhop Cooperative Society | 11507.44 (40.02) | 13910.67 (37.40) | 18491.90 (42.68) | 14636.68 (40.18) |
| b) Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli | 7837.84 (27.26) | 10608.11 (28.52) | 10665.55 (24.62) | 9703.83 (26.64) |
| 4. Subsidy | 9405.26 (32.72) | 12671.53 (34.08) | 14170.06 (32.70) | 12082.28 (33.18) |
| 5. Per hectare investment | 37177.42 | 35532.14 | 41172.80 | 38041.68 |

Subsidy : Area up to 2 hectares ..... 50 per cent or Rs. 20,000/-
Area up to 2 to 6 hectares ..... 35 per cent or Rs. 14,000/-
Area above 6 hectares ..... 20 per cent or Rs. 08,000/-

(Figures in the parentheses are percentages to the total investment cost).

The per farm total investment cost on account of biwall drip irrigation system amounted to Rs. 28750.54, Rs. 37190.31 and Rs. 43327.51 for low, medium and high sugarcane productivity groups, respectively. The per hectare investment cost in biwall drip irrigation system worked out to Rs. 37177.42, Rs. 35532.14 and Rs. 41172.80 for the farms, belonging to the respective groups. Thus, it is revealed that the level of sugarcane productivity was closely related to the magnitude of investment in biwall drip irrigation system at the farm level. At the overall level, the investment in biwall drip irrigation system worked out to Rs. 36422.79 per farm and Rs. 38041.68 per hectare.

As the biwall drip irrigation system is new technology, it is costlier one. The farmers, therefore, depended on loan for biwall drip irrigation set and subsidy from the Government. There was one interesting point that not a single farmer could effect the entire or partial investment from his own funds. All of them availed loan facilities from the Sangli District Central Cooperative Bank and Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli. At the overall level, the relative shares of loan from the Sangli District Central Cooperative Bank, loan from Vasantdada Shetkari Sahakari Sakhar Karkhana and subsidy from Government in the total investment cost of

Rs. 36422.79, were 40.18, 26.64 and 33.18 per cent, respectively. The subsidy component thus proved to be the major incentive to the farmers to participate in the joint venture of adopting highly capital intensive high-tech irrigation system on the farms.

The loans of District Central Cooperative Bank are to be repaid within five years time with 15 per cent interest rate. Similarly, the loans obtained from Vasantdada Shetkari Sahakari Sakhar Karkhana are to be repaid within the same period, but at the interest rate of Rs. 16.00 per cent.

# Results and Discussion

# 5. RESULTS AND DISCUSSION

The present study aims at finding out the economic efficiency of drip irrigation in sugarcane production in the command of the lift irrigation project in Sangli district. As discussed earlier, the drip irrigation technology has been introduced in the command of the lift irrigation scheme to irrigate sugarcane. Prior to the adoption of drip irrigation, the farmers used to irrigate sugarcane crop by surface irrigation method. Presently, the crop is being irrigated by biwall drip irrigation system. The installation of biwall drip irrigation unit in the lift irrigation project area required additional capital investment. At the same time, the farmers followed some different types of cultural practices for sugarcane and other crops. There was water and labour saving on account of adoption of biwall drip irrigation technology. The costs and returns structure of sugarcane and other crops also changed to a greater extent as a result of adoption of new technology.

In the present Chapter, efforts are made to delineate in detail all the changes resulting from introduction of biwall drip irrigation system in the command of the lift irrigation project. Mostly, the 'before' and 'after' approach has been adopted in the analysis in order to find out economic efficiency of drip irrigation in sugarcane in the study area.

## 5.1 Capital Investment Cost for Cooperative Lift Irrigation Scheme

The Vasantdada Cooperative Lift Irrigation Scheme was started in the year 1965. The total cost on account of completion of this lift irrigation scheme was Rs. 14.56 lakhs. The details of the investment cost for the lift irrigation scheme are given in Table 11.

Table 11. Capital investment cost of the lift irrigation scheme

| Particulars | Amount (Rs. in lakhs) | Percentage |
|---|---|---|
| 1. Jackwell | 3.09 | 21.22 |
| 2. Intake well | 1.03 | 7.07 |
| 3. Pump house | 0.18 | 1.23 |
| 4. Pumping machinery and electrical machinery | 4.37 | 30.01 |
| 5. Pipe line system | | |
| (a) Rising main | 1.30 | 8.92 |
| (b) Intake pipe | 1.50 | 10.30 |
| (c) Distributories | 1.55 | 10.64 |
| Sub-total | 4.35 | 29.87 |
| 6. Delivery chamber | 1.50 | 10.30 |
| 7. Furniture | 0.04 | 0.27 |
| Total | 14.56 | 100.00 |

Out of the total capital investment cost of Rs. 14.56 lakhs, the cost on account of completion of jack-well, intake well and pump house was Rs. 3.09 lakhs, Rs. 1.03 lakhs and Rs. 0.18 lakhs, respectively. All these three items together shared 29.52 per cent of the total capital investment cost. The electric motor pumps and other accessories shared 30.01 per cent of the total capital investment cost. The pipe line system included the components of rising main pipe line, intake pipe line and distributories, all of which together contributed 29.87 per cent of the total capital investment cost. The shares of costs on account of delivery chambers and other items in the total capital investment cost were 10.30 and 0.27 per cent, respectively.

## 5.2 Capital Investment Costs for Biwall Drip Irrigation Unit

The details of capital investment costs for the biwall drip irrigation unit are presented in Table 12.

The total capital investment cost for the whole unit was Rs. 56.27 lakhs. The major components of the biwall drip irrigation unit are the biwall pipe line/ lateral pipe line, filter, main pipe line, electric motor, pumps, etc. Among the various items of capital investment, the investment cost on account of main pipe line, sub-main pipe line, lateral pipe line/biwall pipe line was

Table 12. Capital investment costs of the biwall drip irrigation unit

| | Particulars | Amount (Rs. in lakhs) | Percentage |
|---|---|---|---|
| 1. | Main pipe line | 5.02 | 8.92 |
| 2. | Sub-main pipe line | 3.30 | 5.86 |
| 3. | Lateral pipe line | 5.11 | 9.09 |
| 4. | Biwall pipe line | 25.07 | 44.55 |
| 5. | Other parts | | |
| | a) Valves (3, 2, 0.75, 0.5") | 0.55 | 0.98 |
| | b) Filter (2 and 3") | 6.88 | 12.23 |
| | c) Pressure guage | 0.03 | 0.05 |
| | d) Bipass (2 and 3") | 3.30 | 5.86 |
| | e) Backwash (2 and 3") | 0.08 | 0.15 |
| | f) Ventury section | 0.16 | 0.28 |
| 6. | Electric motors and pumps | | |
| | a) 3 H.P. | 0.09 | 0.16 |
| | b) 5 H.P. | 0.21 | 0.37 |
| | c) 7.5 H.P. | 0.95 | 1.69 |
| | d) 10 H.P. | 2.87 | 5.10 |
| | e) 12.5 H.P. | 0.41 | 0.73 |
| | Sub-total | 4.53 | 8.05 |
| 7. | Miscellaneous expenses | 2.24 | 3.98 |
| 8. | Total investment cost | 56.27 | 100.00 |
| 9. | Less subsidy | 19.50 | 34.65 |
| 10. | Net investment cost | 36.77 | 65.35 |
| 11. | Sources of funds | | |
| | a) Loan from Sangli District Central Coop. Bank, Sangli | 21.77 | 38.69 |
| | b) Loan from Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli | 15.00 | 26.66 |

Rs. 5.02 lakhs, Rs. 3.30 lakhs, Rs. 5.11 lakhs and Rs. 25.07 lakhs, respectively. All these components of pipe line together shared 68.42 per cent of the total investment cost.

The investment in electric motors and pumps of various capacities was Rs. 4.53 lakhs and it shared 8.05 per cent of the total capital investment cost for the entire unit. Among the other parts of drip irrigation unit, valves, filters, pressure guage, bipass, backwash and ventury section were the important ones. The investment cost of all these parts was Rs. 11.00 lakhs, which was 19.55 per cent of the total capital investment cost.

As this was a modern technology, it required a huge amount of capital cost. Some parts of this unit have been manufactured from various types of material which were much costlier in the market. Also the taxes on raw material and industrial components were more due to which the cost of components of biwall unit was high.

## 5.3 Annual Operating Cost of Lift Irrigation Scheme

The details of annual operating cost of the lift irrigation scheme are given in Table 13.

The annual operating cost of the lift irrigation scheme was Rs. 3.79 lakhs which was composed of Rs. 2.00 lakhs (52.77 per cent) as fixed cost and Rs. 1.79 lakhs

(47.23 per cent) as variable cost. Among the fixed costs, interest on fixed capital was the major item sharing 25.25 per cent of the total operating cost. Depreciation and insurance charges contributed 9.61 and 17.43 per cent of the total operating cost. Among the different items of variable cost, salaries and wages, electricity and water charges, and repair and maintenance charges were the major items which shared 27.45, 12.00 and 4.64 per cent of the total operating cost of the lift irrigation scheme. The expenses on account of office, stationery, audit fee, travel, etc, formed 2.87 per cent of the total operating cost.

Table 13. Annual operating cost of the lift irrigation scheme

| | Particulars | Amount (Rs.) | Percentage |
|---|---|---|---|
| A. | Fixed costs | | |
| | 1. Interest | 95600 | 25.25 |
| | 2. Depreciation | 36400 | 9.61 |
| | 3. Office rent | 1800 | 0.48 |
| | 4. Insurance of machinery | 66000 | 17.43 |
| | Sub-total | 199800 | 52.77 |
| B. | Variable costs | | |
| | 1. Salaries and wages | 103942 | 27.45 |
| | 2. Repair and maintenance | 17539 | 4.64 |
| | 3. Elec. and water charges | 45462 | 12.00 |
| | 4. Expenditure on office | 3000 | 0.79 |
| | 5. Stationery | 1500 | 0.40 |
| | 6. Audit fees | 3550 | 0.94 |
| | 7. Travelling expenses | 2800 | 0.74 |
| | 8. Miscellaneous expenses | 1000 | 0.27 |
| | Sub-total | 178793 | 47.23 |
| | Total cost ..... | 378593 | 100.00 |

## 5.4 Annual Operating Cost of Biwall Drip Irrigation Unit

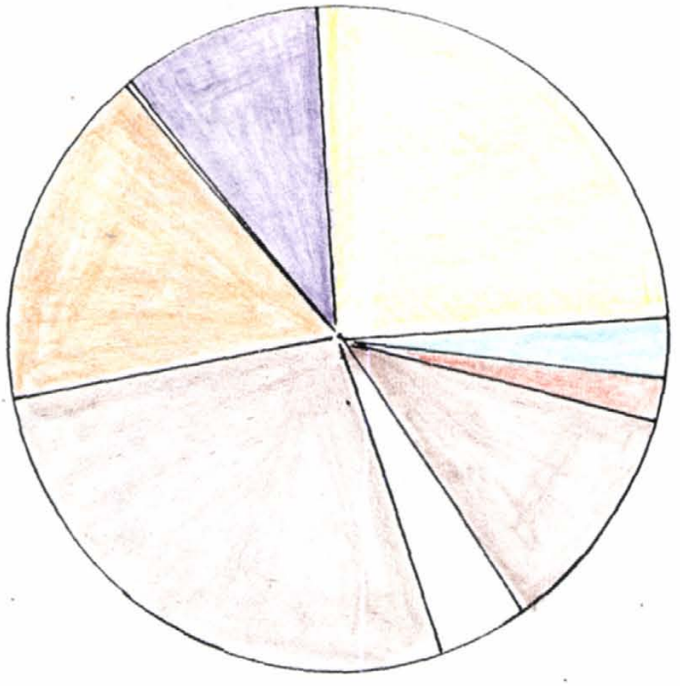
The details of the annual operating cost of biwall drip irrigation unit are presented in Table 14.

Table 14. Annual operating cost of biwall drip irrigation unit

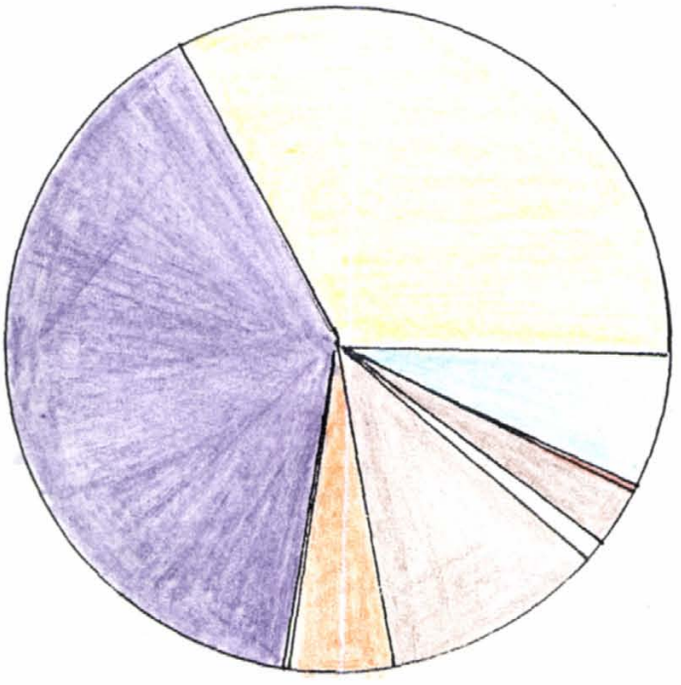
| Particulars | Amount (Rs.) | Percentage |
|---|---|---|
| A. Fixed costs | | |
| 1. Interest on capital investment | | |
| a) For farmers | 265464 | 20.02 |
| b) For sugar factory | 178136 | 13.44 |
| 2. Depreciation on capital investment | | |
| a) For farmers | 294160 | 22.19 |
| b) For sugar factory | 233098 | 17.59 |
| 3. Insurance | 66000 | 4.98 |
| Sub-total | 1036858 | 78.22 |
| B. Variable costs | | |
| 4. Salaries and wages | 147885 | 11.16 |
| 5. Electricity charges | 45648 | 3.44 |
| 6. Repair of electric motors | 15000 | 1.13 |
| 7. Repair of lateral/joiner | 300 | 0.02 |
| 8. Filter paper | 200 | 0.02 |
| 9. Chemicals, oils, etc. | 10800 | 0.81 |
| 10. Urea application | 62000 | 4.68 |
| 11. Water lifting tax | 360 | 0.02 |
| 12. Office stationery | 1000 | 0.08 |
| 13. Office rent | 2500 | 0.19 |
| 14. Travelling expenses | 3000 | 0.23 |
| Sub-total | 288693 | 21.78 |
| Total ..... | 1325551 | 100.00 |

The total operating cost of the biwall drip irrigation unit was Rs. 13.26 lakhs per annum. It included fixed cost of Rs. 10.37 lakhs (78.22 per cent) and variable cost of Rs. 2.89 lakhs (21.78 per cent). Annual interest cost and depreciation were the major items of fixed cost and individually they shared 33.46 and 39.78 per cent of the total operating cost. Among the various items of variable cost, salaries and wages, electricity charges, repairs and urea application shared 11.16, 3.44, 1.13 and 4.68 per cent of the total operating cost, respectively. The expenses on account of filter paper, oil chemicals, stationery charges, water lifting tax, office rent, travelling charges, etc. together contributed 1.35 per cent of the total operating cost of the biwall drip irrigation unit.

If we compare the annual operating cost of biwall drip irrigation unit with that of lift irrigation scheme, it could be revealed that the annual operating cost of the former was much higher than that of the latter mainly on account of higher amount of depreciation and interest charges. The annual expenditure on salaries and wages of the biwall drip irrigation unit was also higher than that of the lift irrigation scheme, indicating thereby higher labour requirement for operating the biwall drip irrigation unit. The break-up of the annual operating costs of the lift irrigation scheme and biwall drip irrigation unit is depicted in Fig. 4.



A) Lift irrigation scheme



B) Biwall drip irrigation unit

REFERENCES

- Interest
- Depreciation
- Office rent
- Insurance of mechinery
- Salaries and wages
- Repairing charges
- Electricity charges
- Office expenditure
- Others

Fig. 4. Annual operating costs.

## 5.5 Per Hectare Labour and Machinery Power Requirements for Sugarcane on Sample Farms

The drip irrigation technology is expected to have impact on the cultural practices of sugarcane crop. Moreover, it is expected that the operationwise labour and machinery requirements of sugarcane grown under surface irrigation method could be somewhat different than that of the crop grown under biwall drip irrigation method. In order to verify this impact at depth, the details of the per hectare operationwise requirement of labour and machinery for sugarcane crop grown under both the methods are presented in Table 15.

It could be revealed from the table that the per hectare requirements of human labour, bullock labour and tractor hours for sugarcane crop have declined considerably when grown under biwall drip irrigation method in comparison with the surface irrigation method. At the overall level, the per hectare requirement of men and women labour declined from 124.90 days and 129.83 days to 67.12 and 116.33 days, respectively, for the crop when grown under biwall drip irrigation method. The per hectare requirement of bullock labour declined slightly and that of tractor hours remained mostly the same for the crop grown under both the methods.

The critical examination of the per hectare use levels of human labour for sugarcane crop grown under surface

method revealed that the labour use intensity was quite high for the crop in the case of the low sugarcane productivity group of farms as compared to the medium and high sugarcane productivity groups of farms. Moreover, there existed inverse relationship between the per hectare labour use intensity and sugarcane productivity on the sample farms. The per hectare use level of bullock labour, however, showed direct relationship with the sugarcane productivity; whereas the requirement of per hectare tractor hours remained mostly the same among the various sugarcane productivity groups of farms before installation of biwall drip irrigation unit.

When grown under biwall drip irrigation method, the per hectare requirements of men labour, women labour and bullock labour for sugarcane crop declined by about 54 to 64 mandays, 6 to 20 women days and 0 to 2.50 pair days, respectively, as compared to surface irrigation method, among the different sugarcane productivity groups of farms. The per hectare use level of tractor hours remained the same for the crop grown under both the methods among all the sugarcane productivity groups of farms. Simultaneously, it is observed that the extent of variability in the per hectare use levels of human labour for sugarcane crop was relatively high among the different sugarcane productivity groups of sample farms when grown

Table 15. Per hectare operationwise labour and machinery power requirements for sugarcane crop

| Operations | Low productivity group | | | | Medium productivity group | | | |
|---|---|---|---|---|---|---|---|---|
| | Men labour (days) | Women labour (days) | Bullock labour (pair days) | Machinery (hrs) | Men labour (days) | Women labour (days) | Bullock labour (pair days) | Machinery (hrs) |
| | | | | Before drip irrigation | | | | |
| 1. Preparatory tillage operations | - | - | - | 15.30 | - | - | - | 13.75 |
| 2. Application of manures | 6.27 | - | - | - | 5.64 | - | - | - |
| 3. Planting of setts | 21.54 | 14.67 | 0.33 | - | 24.56 | 20.99 | - | - |
| 4. Interculturing operations | 23.43 | 102.97 | 3.66 | - | 23.53 | 86.15 | 5.08 | - |
| 5. Fertilizer application | 12.77 | - | - | - | 8.31 | - | - | - |
| 6. Irrigation | 41.61 | - | - | - | 36.42 | - | - | - |
| 7. Plant protection measures | - | - | - | - | 0.04 | - | - | - |
| 8. Harvesting | 27.37 | 27.19 | - | - | 24.76 | 24.76 | - | - |
| Total | 132.99 | 144.83 | 3.99 | 15.30 | 123.26 | 131.90 | 5.08 | 13.75 |
| | | | | After drip irrigation | | | | |
| 1. Preparatory tillage operations | - | - | - | 15.47 | - | - | - | 14.87 |
| 2. Application of manures | 6.29 | - | - | - | 6.36 | - | - | - |
| 3. Planting of setts | 20.43 | 15.08 | 0.68 | - | 23.34 | 19.07 | 0.32 | - |
| 4. Interculturing operations | 6.55 | 82.88 | 3.01 | - | 4.20 | 70.19 | 2.29 | - |
| 5. Fertilizer application | 4.87 | - | - | - | 5.00 | - | - | - |
| 6. Irrigation | 4.31 | - | - | - | 4.77 | - | - | - |
| 7. Plant protection measures | - | - | - | - | - | - | - | - |
| 8. Harvesting | 26.68 | 26.68 | - | - | 25.09 | 25.09 | - | - |
| Total | 69.13 | 124.64 | 3.69 | 15.47 | 68.76 | 114.35 | 2.61 | 14.87 |

Table 15 (Contd...)

| Operations | High productivity group | | | | Overall productivity group | | | |
|---|---|---|---|---|---|---|---|---|
| | Men labour (days) | Women labour (days) | Bullock labour (pair days) | Machinery (hrs) | Men labour (days) | Women labour (days) | Bullock labour (pair days) | Machinery (hrs) |
| | | | | Before drip irrigation | | | | |
| 1. Preparatory tillage operations | - | - | - | 17.07 | - | - | - | 15.39 |
| 2. Application of manures | 5.24 | - | - | - | 5.64 | - | - | - |
| 3. Planting of setts | 20.54 | 16.13 | - | - | 22.30 | 17.63 | 0.11 | - |
| 4. Interculturing operations | 22.63 | 77.84 | 5.74 | - | 23.16 | 86.98 | 4.99 | - |
| 5. Fertilizer application | 10.52 | - | - | - | 10.22 | - | - | - |
| 6. Irrigation | 38.14 | - | - | - | 38.28 | - | - | - |
| 7. Plant protection measures | 0.06 | - | - | - | 0.04 | - | - | - |
| 8. Harvesting | 24.43 | 24.43 | - | - | 25.26 | 25.22 | - | - |
| Total | 121.56 | 118.40 | 5.74 | 17.07 | 124.90 | 129.83 | 5.10 | 15.39 |
| | | | | After drip irrigation | | | | |
| 1. Preparatory tillage operations | - | - | - | 17.35 | - | - | - | 15.94 |
| 2. Application of manures | 5.32 | - | - | - | 5.96 | - | - | - |
| 3. Planting of setts | 21.06 | 18.78 | - | - | 21.49 | 17.89 | 0.33 | - |
| 4. Interculturing operations | 3.42 | 67.88 | 3.24 | - | 4.54 | 72.16 | 2.83 | - |
| 5. Fertilizer application | 4.30 | - | - | - | 4.71 | - | - | - |
| 6. Irrigation | 4.75 | - | - | - | 4.64 | - | - | - |
| 7. Plant protection measures | 0.28 | - | - | - | 0.10 | - | - | - |
| 8. Harvesting | 25.53 | 25.53 | - | - | 25.68 | 25.68 | - | - |
| Total | 64.66 | 112.19 | 3.24 | 17.35 | 67.12 | 116.33 | 3.16 | 15.94 |

under surface irrigation method as compared to biwall drip irrigation method.

It is further observed that the decline in per hectare requirement of human labour was more prominent for the operations such as interculturing, top-dressing and irrigation. The per hectare requirement of human labour, bullock labour and tractor hours remained more or less the same for the operations such as preparatory tillage, application of manure, planting and harvesting of sugarcane grown under surface and biwall drip irrigation methods. This pattern of change in the per hectare operationwise requirement of human labour due to introduction of biwall drip irrigation method was common among all the sugarcane productivity groups of sample farms. The magnitude of this change, however, varied slightly among the sugarcane productivity groups of sample farms.

It is interesting to note that, with the introduction of biwall drip irrigation method, the per hectare use levels of human labour for sugarcane crop grown under surface irrigation method declined significantly on the low and medium sugarcane productivity groups of farms. This decrease in the per hectare use levels of human labour for sugarcane crop was observed mostly for the interculturing and irrigation operations.

## 5.6 Per Hectare Other Input Requirements of Sugarcane

The sugarcane grown under biwall drip irrigation method and surface irrigation method required various other inputs besides human labour, bullock labour and tractor power. These other inputs included sugarcane setts, manures, fertilizers and plant protection chemicals. The per hectare use levels of these inputs for sugarcane crop on various sugarcane productivity groups of farms are presented in Table 16.

The per hectare requirement of planting material of sugarcane was approximately 25600 setts, at the overall level before drip irrigation. There was no significant difference in the per hectare use level of sugarcane setts among different sugarcane productivity groups of farms. On installation of biwall drip irrigation, the farmers became more conscious about plant population. They planted more setts than before for better growth and it resulted in increasing per hectare requirement of sugarcane setts. At the overall level, 26685.62 setts were required for planting sugarcane crop on one hectare of land under biwall drip irrigation method. The per hectare use level of sugarcane setts was relatively high on the high sugarcane productivity group of farms as compared to the other groups of farms. The per hectare use level of sugarcane setts for planting sugarcane under surface method, however, decreased

Table 16. Per hectare seeds, manures, fertilizers and plant protection measures required for sugarcane before and after drip irrigation

| Inputs | Low sugarcane Productivity group | | Medium sugarcane productivity group | | High sugarcane productivity group | | Overall sugarcane productivity group | |
|---|---|---|---|---|---|---|---|---|
| | Before | After | Before | After | Before | After | Before | After |
| 1. Sugarcane setts | 25100.91 | 26056.03 | 25552.99 | 25732.48 | 26064.07 | 28096.29 | 25640.57 | 26685.62 |
| 2. Manures (cartloads) | 38.93 | 37.15 | 31.31 | 31.27 | 32.44 | 30.18 | 33.56 | 32.45 |
| 3. Fertilizers (kg) | | | | | | | | |
| N | 708.80 | 412.08 | 500.91 | 444.20 | 760.58 | 463.86 | 649.69 | 442.75 |
| $P_2O_5$ | 486.62 | 186.89 | 319.47 | 206.84 | 606.52 | 216.36 | 469.00 | 205.02 |
| $K_2O$ | 391.39 | 275.21 | 298.06 | 318.43 | 420.12 | 350.82 | 366.95 | 318.66 |
| 4. Plant protection chemicals (kg/ml) | - | - | 0.04 lit. | - | 0.10 lit. | 0.41 lit. | 0.04 lit. | 0.14 lit |

on installation of biwall drip irrigation unit on all the farms. The per hectare use levels of farmyard manure were observed to be somewhat similar in all the sugarcane productivity groups of farms for surface irrigation method and biwall drip irrigation method. The use of farm yard manure was slightly high in the case of the low sugarcane productivity groups of farms.

It was observed that the use of fertilizers for sugarcane crop was considerably low when grown under biwall drip irrigation method as compared to that of surface irrigation method. At the overall level, the per hectare use levels of N, $P_2O_5$ and $K_2O$ were 650, 469 and 367 kg, respectively, for the crop grown under surface irrigation method. On adoption of biwall drip irrigation technology, the per hectare use levels of N, $P_2O_5$ and $K_2O$ decreased to 443.0, 205.0 and 319.0 kg, respectively. The farmers decided to adopt the practice of applying low levels of fertilizers to the crop because all the fertilizers applied were fully utilized by the plants. The fertilizer losses were very low as some of them were applied through water. The use of plant protection chemicals was mostly common for sugarcane grown under surface irrigation method because of the problem of diseases and pests. The problem of diseases and pests was not serious in the case of the sugarcane crop when grown under biwall drip irrigation method.

Plate-1 : Uneven distribution of irrigation water in surface irrigation method





Plate-2 : Profused weed growth competing with crop in surface irrigation method

## 5.7 Cost of Production of Sugarcane

The magnitude and structure of cost of production of sugarcane crop grown under surface irrigation method and biwall drip irrigation method varied in accordance with the differentials in the use levels of various inputs for the crop. The details of per hectare cost of production of sugarcane grown under surface irrigation method and biwall drip irrigation method are given separately in Tables 17 and 18, respectively for all the sugarcane productivity groups of farms. The per hectare total cost of production of sugarcane grown under different methods of irrigation is composed of fixed cost and variable cost. The structure of total cost of production of sugarcane presented in these tables, however, is as per the standardised cost concepts adopted in the farm management studies. The cost of production is, therefore, computed as Cost-A (which includes items such as hired human labour, total bullock labour, planting material, manures, fertilizers, insecticides and pesticides, irrigation charges, land taxes and cesses, depreciation, repairing and hiring charges, transport and marketing and interest on working capital, etc.), Cost-B (which includes rental value of owned land and interest on fixed capital investment and interest on investment of drip irrigation unit in addition to Cost-A) and Cost-C (which includes imputed value of family labour in addition to Cost-B).

Table 17. Per hectare itemwise cost of production of sugarcane on sample farms before drip irrigation (surface method)

(Rupees)

| | Cost items | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|---|
| | | Low | Medium | High | |
| 1. | Hired human labour | 2963.32 (10.55) | 2927.06 (12.61) | 3069.19 (12.44) | 2986.52 (11.94) |
| 2. | Total bullock labour | 320.00 (1.14) | 406.45 (1.75) | 459.49 (1.86) | 406.12 (1.62) |
| 3. | Planting material | 2593.57 (9.23) | 2394.00 (10.32) | 2526.31 (10.25) | 2492.12 (9.96) |
| 4. | Manures | 1212.11 (4.31) | 1101.84 (4.75) | 973.45 (3.95) | 1079.10 (4.32) |
| 5. | Fertilizers | 6480.55 (23.06) | 4832.18 (20.82) | 6518.21 (26.43) | 5869.33 (23.47) |
| 6. | Insecticides and pesticides | - | 13.82 (0.06) | 11.44 (0.05) | 9.61 (0.04) |
| 7. | Irrigation charges | 1922.93 (6.84) | 1843.31 (7.94) | 398.16 (1.61) | 1310.01 (5.24) |
| 8. | Land taxes and cesses | 57.56 (0.20) | 52.02 (0.22) | 58.64 (0.24) | 56.08 (0.22) |
| 9. | Depreciation, repairing and hiring charges | 2550.80 (9.08) | 1606.08 (6.92) | 2145.89 (8.70) | 2066.54 (8.26) |
| 10. | Transport and marketing | - | - | - | - |
| 11. | Interest on working capital | 1176.55 (4.19) | 986.49 (4.25) | 1050.45 (4.26) | 1057.90 (4.23) |
| | Cost-A | 19277.39 (68.60) | 16163.25 (69.64) | 17211.23 (69.79) | 17333.33 (69.30) |
| 12. | Rental value of land | 4940.36 (17.58) | 4581.02 (19.74) | 5013.73 (20.32) | 4832.02 (19.32) |
| 13. | Interest on fixed capital | 2738.48 (9.74) | 1603.92 (6.92) | 1890.84 (7.67) | 2035.12 (8.14) |
| | Cost-B | 26956.23 (95.92) | 22348.19 (96.30) | 24115.80 (97.78) | 24200.47 (96.76) |
| 14. | Family human labour | 1145.30 (4.08) | 856.35 (3.70) | 547.05 (2.22) | 810.50 (3.24) |
| | Cost-C | 28101.53 (100.00) | 23204.54 (100.00) | 24662.85 (100.00) | 25010.97 (100.00) |

(Figures in the parentheses indicate percentages to Cost-C).

### 5.7.1 Per hectare cost of production of sugarcane grown under surface irrigation method

The total cost of production (i.e. Cost-C) of sugarcane grown under surface irrigation method worked out to Rs. 25010.97 per hectare, at the overall level. Among the different items of production cost, the important ones were human labour (both family and hired), planting material, fertilizers, depreciation and machinery charges, interest on working capital, rental value of owned land and interest on fixed capital investment with their proportionate shares of 15.18, 9.96, 23.47, 8.26, 4.23, 19.32 and 8.14 per cent, respectively, in the total cost of production. The expenditure on account of irrigation charges was only 5.24 per cent of the total cost of production, whereas the share of manures in the total cost was 4.32 per cent. The cost of production at Cost-A and Cost-B levels worked out to Rs. 17333.33 and Rs. 24200.47 per hectare and they formed 69.30 and 96.76 per cent of the total cost, respectively.

Among the sugarcane productivity groups of farms, the per hectare total cost of production of sugarcane ranged between Rs. 23204.54 and Rs. 28101.53, the lowest and the highest production cost being, respectively, for the medium and low sugarcane productivity groups of farms. The structure of the cost of production of sugarcane was more or less the same with slight variations among the low, medium

and high sugarcane productivity groups of farms. In general, the per hectare cost on account of individual items of cost was relatively high in the case of the low sugarcane productivity group of farms followed by high and medium sugarcane productivity groups of farms.

### 5.7.2 Per hectare cost of production of sugarcane grown under biwall drip irrigation method

The total cost of production (i.e., Cost-C) of sugarcane grown under biwall drip irrigation method worked out to Rs. 37365.50 per hectare, at the overall level. Among the different items of production cost, the important ones were family and hired human labour, planting material, fertilizers, depreciation on machinery and drip irrigation unit and machinery charges, interest on working capital, rental value of owned land and interest on fixed capital investment and drip irrigation unit with their proportionate shares of 9.88, 8.07, 8.13, 19.20, 3.99, 19.13 and 12.67 per cent, respectively, in the total cost of production. The expenditure on irrigation was relatively higher than that of surface irrigation method. The cost of production at Cost-A and Cost-B levels worked out to Rs. 24455.19 and Rs. 36336.24 per hectare and they formed 65.45 and 97.25 per cent of the total cost, respectively.

Among the sugarcane productivity groups of farms, the per hectare total cost of production of sugarcane ranged

Table 18. Per hectare itemwise cost of production of sugarcane on the sample farms after drip irrigation (biwall drip irrigation method).

(Rupees)

| | Cost items | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|---|
| | | Low | Medium | High | |
| 1. | Hired human labour | 2550.23 (6.96) | 2647.67 (7.67) | 2765.76 (6.94) | 2664.70 (7.13) |
| 2. | Total bullock labour | 370.68 (1.01) | 261.14 (0.76) | 324.67 (0.82) | 313.90 (0.84) |
| 3. | Planting material | 3036.63 (8.29) | 3095.54 (8.96) | 2917.32 (7.33) | 3014.39 (8.07) |
| 4. | Manures | 1875.00 (5.12) | 2308.91 (6.69) | 1471.33 (3.70) | 1885.22 (5.05) |
| 5. | Fertilizers | 2654.82 (7.25) | 2659.93 (7.70) | 3691.97 (9.27) | 3036.44 (8.13) |
| 6. | Insecticides and pesticides | - | - | 21.53 (0.05) | 7.89 (0.02) |
| 7. | Irrigation charges | 4978.44 (13.59) | 4522.29 (13.10) | 4973.07 (14.49) | 4810.25 (12.87) |
| 8. | Land taxes and cesses | 57.56 (0.16) | 52.02 (0.15) | 58.64 (0.15) | 56.08 (0.15) |
| 9. | Depreciation, repairing and hiring charges of implements and machinery | 2846.59 (7.77) | 1826.52 (5.29) | 2275.04 (5.71) | 2274.33 (6.09) |
| 10. | Depreciation on drip irrigation unit | 4768.88 (13.02) | 4259.07 (12.33) | 5631.24 (14.14) | 4899.42 (13.11) |
| 11. | Transport and marketing | - | - | - | - |
| 12. | Interest on working capital | 1504.02 (4.11) | 1406.15 (4.07) | 1568.49 (3.94) | 1492.57 (3.99) |
| | Cost-A | 24642.85 (67.28) | 23039.24 (66.72) | 25699.06 (64.54) | 24455.19 (65.45) |
| 13. | Rental value of land | 5564.22 (15.18) | 6755.83 (19.57) | 8592.55 (21.58) | 7146.97 (19.13) |
| 14. | Interest on investment in fixed capital assets | 2738.48 (7.47) | 1603.92 (4.64) | 1890.84 (4.75) | 2035.12 (5.45) |
| 15. | Interest on investment in drip irrigation unit | 2627.00 (7.17) | 2346.18 (6.79) | 3102.21 (7.79) | 2698.94 (7.22) |
| | Cost-B | 35572.55 (97.10) | 33745.17 (97.72) | 39284.66 (98.66) | 36336.24 (97.25) |
| 16. | Family human labour | 1063.56 (2.90) | 787.52 (2.28) | 534.20 (1.34) | 1029.28 (2.75) |
| 17. | Cost-C | 36636.11 (100.00) | 34532.69 (100.00) | 39818.86 (100.00) | 37365.50 (100.00) |

(Figures in the parentheses indicate percentages to Cost-C).

between Rs. 34532.69 and Rs. 39818.86, the lowest and the highest production cost being for medium and high sugarcane productivity groups of farms, respectively. The structure of the cost of production of sugarcane was more or less the same with slight variations among the low, medium and high sugarcane productivity groups of farms. In general, the per hectare cost on account of individual items of cost was relatively high in the case of the high sugarcane productivity group of farms followed by low and medium sugarcane productivity groups of farms.

## 5.8 Per Hectare Yield of Sugarcane Crop

The estimates of the per hectare output of sugarcane grown under surface irrigation method and biwall drip irrigation method are indicated in Table 19.

It is observed that the per hectare output of sugarcane was 91.14 tonnes under surface irrigation method, at the overall level. As against this, the per hectare output of sugarcane was 115.46 tonnes, when grown under biwall drip irrigation system. Thus, the difference in the per hectare output of sugarcane grown under surface irrigation and biwall drip irrigation method was 24.32 tonnes.

Among the different sugarcane productivity groups of farms, the pattern of difference in the per hectare output of sugarcane when grown under surface irrigation and biwall

Table 19. Per hectare output and gross returns of sugarcane crop grown under surface irrigation and biwall drip irrigation methods

| Irrigation method | Sugarcane productivity groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Low | | Medium | | High | | Overall | |
| | Quantity (Tons) | Value (Rs.) | Quantity (Tons) | Value (Rs.) | Quantity (Tones) | Value ( Rs.) | Quantity (Tons) | Value (Rs.) |
| Surface irrigation method | 89.48 | 28103.27 | 90.00 | 27983.01 | 93.32 | 30543.03 | 91.14 | 28892.61 |
| Biwall drip irrigation method | 87.88 | 33385.30 | 110.10 | 40535.00 | 141.00 | 51555.30 | 115.46 | 42881.80 |

drip irrigation methods was quite different. As a matter of fact, the per hectare yield of sugarcane when grown under biwall drip irrigation method was about 1.60 tonnes lower than that of the crop grown under surface irrigation method on the low sugarcane productivity group of farms. The marginal decrease in the output of sugarcane grown under biwall drip irrigation method was partly due to the inadequate water supply to the crop. This has resulted from some technical defects of the system in delivering irrigation water at constant pressure. In the case of the medium and high sugarcane productivity groups of farms, however, the per hectare output of sugarcane when grown under biwall drip irrigation method was relatively higher to the extent of 20.10 and 47.68 tonnes than that of the crop grown under surface irrigation method. The biwall drip irrigation method, thus, resulted into the increase in per hectare output of sugarcane on the sample farms.

The per hectare gross returns of sugarcane also varied in accordance with the change in the production of the crop resulting from adoption of drip irrigation technology on the sample farms. At the overall level, the gross return of sugarcane crop was Rs. 42881.80 per hectare when grown under biwall drip irrigation method as against Rs. 28892.61 per hectare when grown under surface irrigation method. Among the farms belonging to the various sugarcane

productivity groups, the per hectare gross returns of sugarcane crop when grown under drip irrigation was higher by an amount of Rs. 5282.03, Rs. 12551.99 and Rs. 20012.27 than that of the crop when grown under surface irrigation method, respectively on low, medium and high sugarcane productivity groups of farms. This increase in the per hectare gross returns of sugarcane crop grown under biwall drip and surface irrigation methods was partly due to yield difference and partly due to rise in the price.

Thus, excepting for the low sugarcane productivity groups of farms, the high-tech drip irrigation system has resulted into increasing the per hectare output and gross returns of sugarcane crop in the lift irrigation command area.

## 5.9 Per Hectare Production Costs, Gross Returns and Net Returns From Sugarcane Crop

It is evident from the preceding discussion that the adoption of biwall drip irrigation technology for sugarcane crop has resulted into changes in its production cost, output and gross returns. Ultimately, the per hectare net returns of the crop have undergone a change due to adoption of drip irrigation technology. The details of the per hectare net returns over variable cost and total cost of production of sugarcane crop grown under surface irrigation method and biwall drip irrigation method are given in Table 20.

Table 20. Per hectare costs, gross returns and net returns from sugarcane cultivation

(Rupees)

| | Particulars | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|---|
| | | Low | Medium | High | |
| | | Before drip irrigation | | | |
| 1. | Variable cost | 17871.89 (63.60) | 15413.52 (66.42) | 15612.39 (63.30) | 16077.29 (64.28) |
| 2. | Fixed cost | 10229.64 (36.40) | 7791.02 (33.58) | 9050.46 (36.70) | 8933.68 (35.72) |
| 3. | Total cost | 28101.53 (100.00) | 23204.54 (100.00) | 24662.85 (100.00) | 25010.97 (100.00) |
| 4. | Gross returns | 28103.27 | 27983.01 | 30543.03 | 28892.61 |
| 5. | Net returns over variable cost | 10231.38 | 12569.49 | 14930.64 | 12815.32 |
| 6. | Net returns over total cost | - 0.26 | 4778.47 | 5880.18 | 3881.64 |
| | | After drip irrigation | | | |
| 1. | Variable cost | 18090.94 (49.38) | 17741.17 (51.38) | 18326.98 (46.03) | 18310.72 (49.00) |
| 2. | Fixed cost | 18545.17 (50.62) | 16791.52 (48.62) | 21491.88 (53.97) | 19054.78 (51.00) |
| 3. | Total cost | 36636.11 (100.00) | 34532.69 (100.00) | 39818.86 (100.00) | 37365.50 (100.00) |
| 4. | Gross returns | 33385.30 | 40535.00 | 51555.30 | 42881.80 |
| 5. | Net returns over variable cost | 15294.36 | 22793.83 | 33228.32 | 24571.08 |
| 6. | Net returns over total cost | -3250.81 | 6002.31 | 11736.44 | 5516.30 |

(Figures in the parentheses indicate percentages to total cost).

The critical examination of the per hectare variable cost, fixed cost, total cost, gross returns and net returns over variable cost and total cost of sugarcane crop grown under surface irrigation method and biwall drip irrigation method reveals that the cost structure as well as returns structure of sugarcane crop have undergone changes due to adoption of drip irrigation technology as discussed earlier. At the overall level, the per hectare net return from sugarcane crop was Rs. 12815.32 over variable cost and the net return over total cost was Rs. 3881.64 when the crop was grown under surface irrigation method before installation of drip irrigation unit. In the case of the sugarcane crop grown under biwall drip irrigation method, however, the net return over variable cost and total cost was Rs. 24571.08 and Rs. 5516.30 per hectare, respectively.

Among the different sugarcane productivity groups of farms, the per hectare net returns over variable cost of sugarcane crop grown under surface irrigation method ranged between Rs. 10231.38 and Rs. 14930.64 before installation of drip irrigation unit, the lowest and the highest net returns being in the case of the low, and high sugarcane productivity groups of farms, respectively. For the sugarcane crop grown under biwall drip irrigation method, the per hectare net return over variable cost was Rs. 15294.36, Rs. 22793.83, and Rs. 33228.32, respectively,

in the case of the low, medium and high sugarcane productivity groups of farms.

At the total cost level, sugarcane crop grown under surface irrigation method before drip irrigation technology and under biwall drip irrigation method suffered a loss of Re. 0.26 and Rs. 3250.81 per hectare, respectively, on the low sugarcane productivity group of farms. In the case of the medium and high sugarcane productivity groups of farms, however, the net return over total cost was Rs. 4778.47 and Rs. 5880.18 for surface irrigation method before drip irrigation technology and Rs. 6002.31 and Rs. 11736.44 for the biwall drip irrigation method, respectively. The drip irrigation technology has thus resulted into maximisation of net returns from sugarcane crop on the medium and high sugarcane productivity groups of farms as compared to the surface irrigation method for the crop.

The comparative picture of per hectare production costs, gross returns and net returns of sugarcane crop grown under surface irrigation method and biwall drip irrigation method is depicted in Fig. 5 and Fig. 6 for the individual sugarcane productivity groups of farms.

## 5.10 Per Hectare Input Use, Production Costs, Output and Returns of Different Crops

Efforts have been made to see whether the adoption of biwall drip irrigation technology has resulted into any

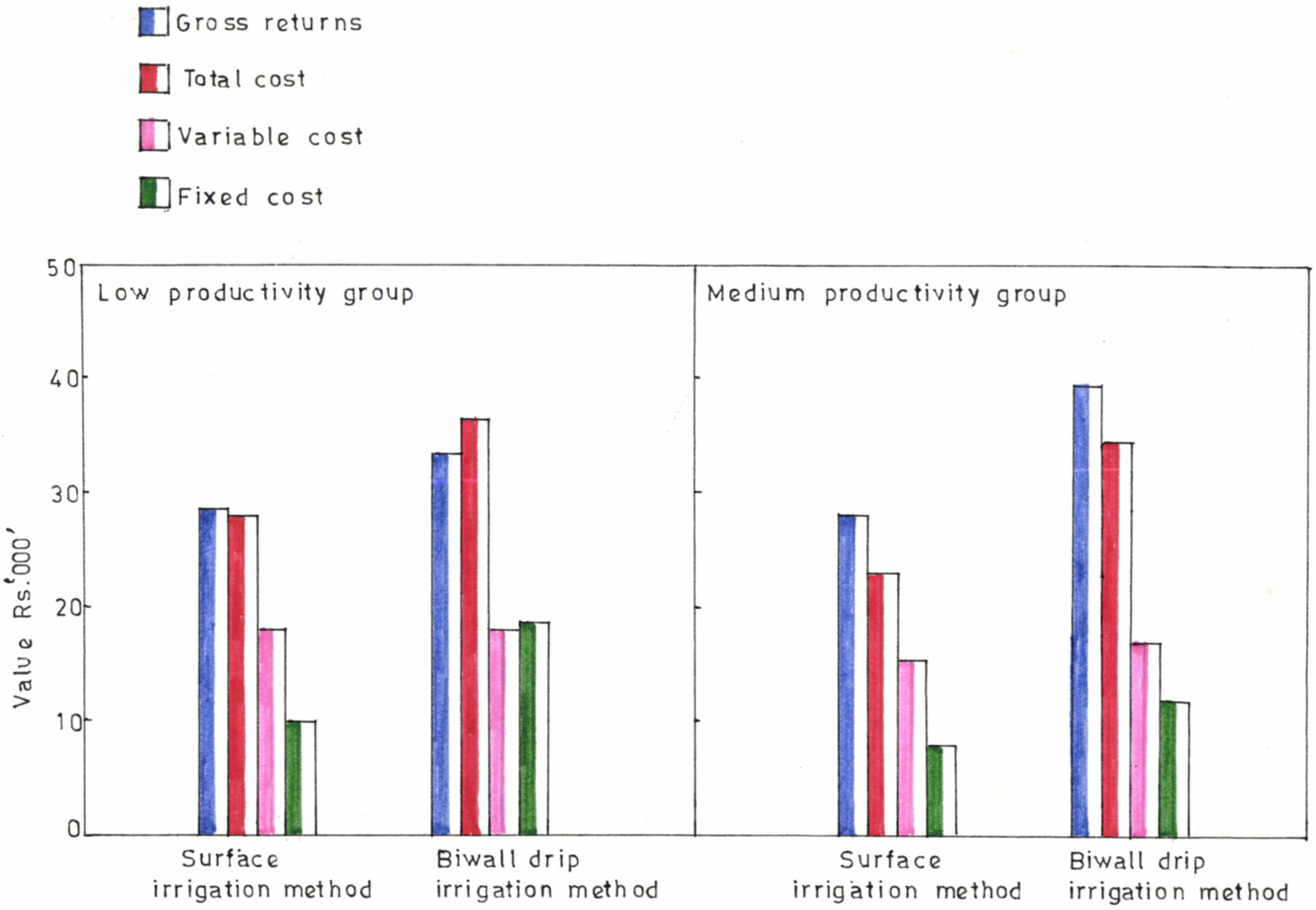



Fig.5. Per hectare production costs gross returns and net returns from sugarcane grown under surface/biwall drip irrigation methods.

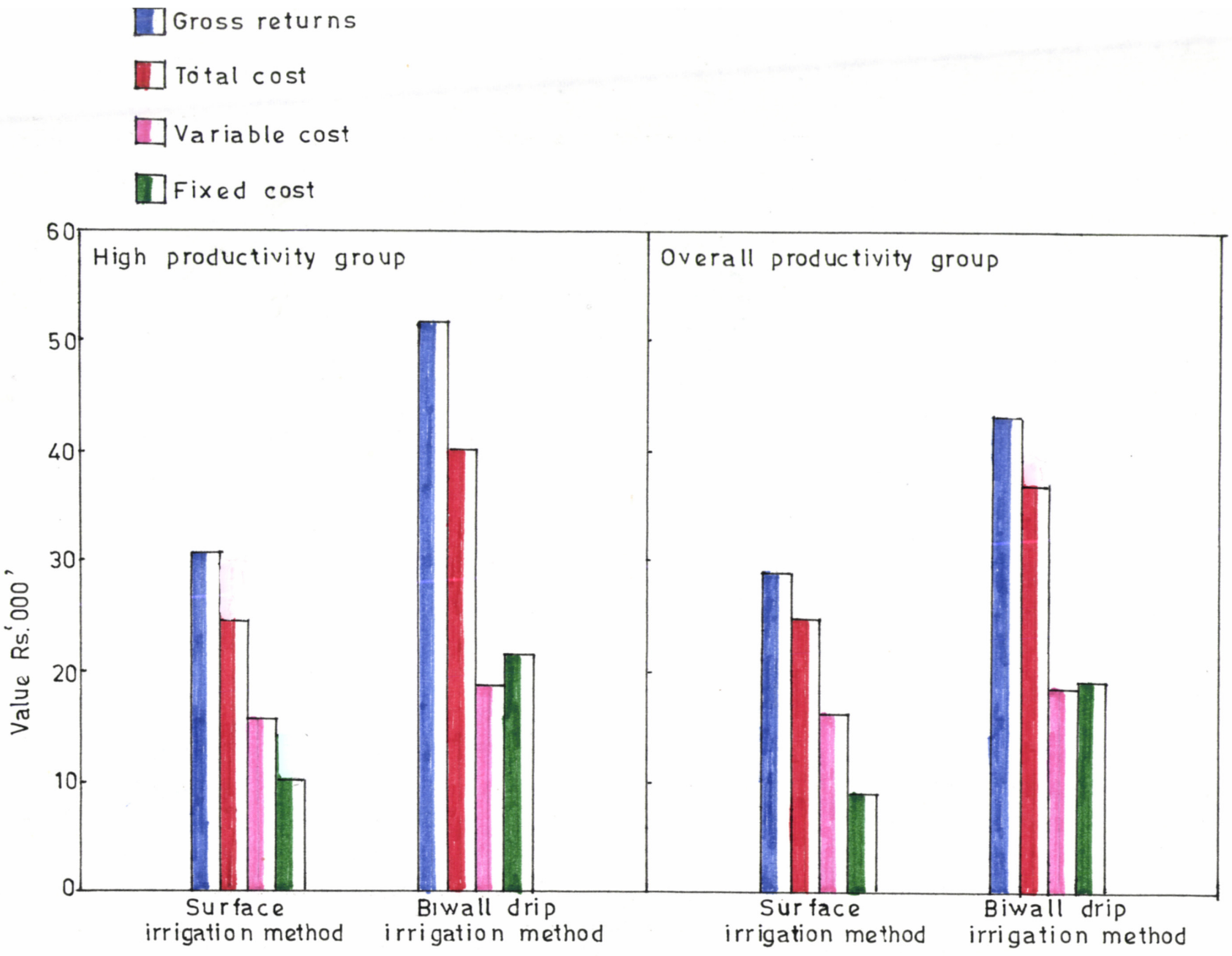



Fig.6. Per hectare production costs gross returns and net returns from sugarcane grown under surface/biwall drip irrigation methods.

changes in the input use structure, production costs, output and returns for other crops which are not being irrigated by biwall drip irrigation method. Tables in Appendices III to VI provide the detail information of above aspects.

The analysis in respect of use levels of various inputs for different crops on sample farms showed that the per hectare use levels of human labour and bullock labour remained almost the same for kharif jowar and soybean after introduction of biwall drip irrigation technology. The per hectare total human labour use for wheat and gram crops, however, increased. There was marginal decrease in the per hectare requirement of labour for grapes. The per hectare seed rates of different crops have remained the same during the period whereas the per hectare use levels of manures have decreased marginally for kharif jowar and increased for wheat and gram during the period. The per hectare use levels of different forms of fertilizers have undergone a marginal change during the period. Among the farms of low, medium and high sugarcane productivity groups of farms, the per hectare use levels of different inputs have shown marginal changes during the period. In general, the per hectare use levels of most of the inputs were relatively high for different crops on the sample farms during the latter period.

The production cost analysis of different crops showed that owing to similar or slightly higher use levels of labour and capital inputs. The per hectare production costs of all the crops turned out to be slightly higher for the crops which were grown after drip irrigation than those of the crops which were grown before drip irrigation. This phenomenon of higher per hectare total cost of production during the latter period was observed even at Cost-A and Cost-B levels of the respective crops in all the sugarcane productivity groups of farms. The proportion of Cost-A in the total production cost of grape was relatively lower after drip irrigation. The reverse was the case in respect of kharif jowar, wheat, gram and sugarcane by surface method after installation of biwall drip irrigation unit.

At the overall level, the per hectare yield levels of all the crops which were grown after biwall drip irrigation were higher by 8.39 to 15.40 per cent than those of the crops grown before drip irrigation, the lowest and the highest yield differences being for soybean and grape crops, respectively. The yields in case of all the crops except gram after drip irrigation were higher in respect of low and high sugarcane productivity groups of farms, wheat in low sugarcane productivity group and kharif jowar in high sugarcane productivity group of farms than for the crops

which were grown before biwall drip irrigation. Thus, the crops grown after biwall drip irrigation showed increase in yields and returns. The per hectare returns of the crops grown after biwall drip irrigation were slightly higher by 1.33 to 23.90 per cent than those of the crops grown before drip irrigation.

## 5.11 Benefits of Biwall Drip Irrigation Method for Sugarcane at the Farm Level

The new irrigation technology for sugarcane crop i.e., biwall drip irrigation method has proved to be more profitable for the cultivators as compared to the surface irrigation method. There have been some better advantages of biwall drip irrigation method over surface irrigation method. The sample farmers using biwall drip irrigation system for sugarcane could save labour cost and expenses on manures and fertilizers as well and could obtain higher output and returns from sugarcane crop as discussed below.

### 5.11.1 Per hectare labour saving

The differentials in the per hectare labour requirement for sugarcane crop grown under surface irrigation and biwall drip irrigation methods are indicated in Table 21.

At the overall level, the per hectare requirement of men, women and bullock labour for sugarcane before drip

Table 21. Per hectare labour saving by biwall drip irrigation method of sugarcane on the sample farms

| Particulars | Farm labour (days) | | |
|---|---|---|---|
| | Men | Women | Bullock pair |
| | Low productivity group | | |
| 1. Use levels before drip irrigation | 132.99 | 144.83 | 3.99 |
| 2. Use levels after drip irrigation | 69.13 | 124.64 | 3.69 |
| 3. Labour saving | 63.86 (48.02) | 20.19 (13.94) | 0.30 (7.52) |
| | Medium productivity group | | |
| 1. Use levels before drip irrigation | 123.26 | 131.90 | 5.08 |
| 2. Use levels after drip irrigation | 68.76 | 114.35 | 2.60 |
| 3. Labour saving | 54.50 (44.22) | 17.55 (13.31) | 2.48 (48.82) |
| | High productivity group | | |
| 1. Use levels before drip irrigation | 121.56 | 118.40 | 5.74 |
| 2. Use levels after drip irrigation | 64.66 | 112.19 | 3.24 |
| 3. Labour saving | 56.90 (46.81) | 6.21 (5.24) | 2.50 (43.55) |
| | Overall productivity group | | |
| 1. Use levels before drip irrigation | 124.90 | 129.83 | 5.10 |
| 2. Use levels after drip irrigation | 67.12 | 116.33 | 3.16 |
| 3. Labour saving | 57.78 (46.26) | 13.50 (10.40) | 1.94 (38.04) |

(Figures in the parentheses indicate labour saving percentages due to adoption of biwall drip irrigation method).

irrigation was of the order of 124.90 days, 129.83 days and 5.10 pair days, respectively, which decreased to 67.12 days, 116.33 days and 3.16 pair days, respectively, for the crop when grown under biwall drip irrigation method. Thus, there was saving of labour to the extent of 57.78 mandays, 13.50 woman days and 1.94 bullock pair days per hectare on account of adoption of biwall drip irrigation technology for sugarcane. The saving of men labour was observed partly due to lesser requirement of labour for irrigating the crop and partly due to release of labour from top dressing operation as certain quantities of fertilizers were applied through irrigation water. Under the biwall drip irrigation method, water was applied in the root zone of sugarcane crop such that the growth of sugarcane remained good and weed population decreased to a considerable extent. Obviously, the huge amount of women labour days required for inter-culturing operations was saved. Thus, the labour saving in sugarcane cultivation under biwall drip irrigation method was observed mainly on account of lesser requirement of labour for performing operations such as irrigation, manuring, top dressing and interculturing as compared to the traditional method of sugarcane cultivation under surface irrigation method.

Looking to the differentials in the per hectare labour requirement for sugarcane grown under surface and

biwall drip irrigation methods on the low, medium and high sugarcane productivity groups of farms, it is observed that the low sugarcane productivity group of farms had the highest labour saving almost to the extent of 64 man days and 20 woman days due to adoption of biwall drip irrigation method. In general, the magnitude of labour saving decreased from low to high sugarcane productivity groups of farms.

5.11.2 Per hectare manures and fertilizers saving

The differentials in the per hectare use levels of manures and fertilizers for sugarcane crop grown under surface irrigation method and biwall drip irrigation method are indicated in Table 22.

At the overall level, the per hectare use of manures was 33.56 cartloads, N 649.69 kg, $P_2O_5$ 469.00 kg and $K_2O$ 366.95 kg for sugarcane grown under surface irrigation method before adoption of biwall drip irrigation technology. For the sugarcane crop grown under biwall drip irrigation method, however, the per hectare use of manures was 32.45 cartloads, N 442.75 kg, $P_2O_5$ 205.00 kg, and $K_2O$ 318.66 kg. There was thus saving of manures and fertilizers to the extent of 1.11 cartloads of manures, 206.94 kg N, 264.00 kg $P_2O_5$ and 48.29 kg $K_2O$ per hectare due to the use of biwall drip irrigation method.

Table 22. Differentials in the per hectare use levels of manures and fertilizers for sugarcane grown under surface irrigation and biwall drip irrigation methods

| Particulars | Before drip irrigation | After drip irrigation | Saving |
|---|---|---|---|
| | Low productivity group | | |
| 1. Manures (Cartloads/ha) | 38.93 | 37.15 | 1.78 (4.57) |
| 2. Fertilizers (kg/ha) | | | |
| (a) N | 708.80 | 412.08 | 296.72 (41.86) |
| (b) $P_2O_5$ | 486.62 | 186.89 | 299.73 (61.59) |
| (c) $K_2O$ | 391.39 | 275.21 | 116.18 (29.68) |
| | Medium productivity group | | |
| 1. Manures (Cartloads/ha) | 31.31 | 31.27 | 0.04 (0.13) |
| 2. Fertilizers (kg/ha) | | | |
| (a) N | 500.91 | 444.20 | 56.71 (11.32) |
| (b) $P_2O_5$ | 319.47 | 206.84 | 112.63 (35.26) |
| (c) $K_2O$ | 298.06 | 318.46 | -20.37 |
| | High productivity group | | |
| 1. Manures (Cartloads/ha) | 32.44 | 30.18 | 2.26 (0.97) |
| 2. Fertilizers (kg/ha) | | | |
| (a) N | 760.58 | 463.86 | 296.72 (39.01) |
| (b) $P_2O_5$ | 606.52 | 216.36 | 390.16 (64.33) |
| (c) $K_2O$ | 420.12 | 350.82 | 69.30 (16.50) |
| | Overall productivity group | | |
| 1. Manures (Cartloads/ha) | 33.56 | 32.45 | 1.11 (3.31) |
| 2. Fertilizers (Kg/ha) | | | |
| (a) N | 649.69 | 442.75 | 206.94 (31.85) |
| (b) $P_2O_5$ | 469.00 | 205.00 | 264.00 (56.29) |
| (c) $K_2O$ | 366.95 | 318.66 | 48.29 (13.16) |

(Figures in parentheses indicate the percentage quantities of the manures and fertilizers saved due to adoption of biwall drip irrigation method).

Among the different sugarcane productivity groups of farms, the maximum saving of manures (2.26 cartloads) was in the high sugarcane productivity group of farms. So far as fertilizers are concerned, the saving in N and $P_2O_5$ ranged between 56.71 to 296.72 kg and 112.63 to 390.16 kg per hectare, the minimum and maximum saving being in the case of the medium and low sugarcane productivity groups of farms, respectively. The highest $K_2O$ was saved in low productivity group of farms (116.18 kg/ha). In the case of the medium sugarcane productivity group of farms, however, there was increase in the use of $K_2O$ by 20.37 kg per hectare for the crop when grown under biwall drip irrigation method.

The saving in fertilizers under biwall drip irrigation method was possible because of application of N through irrigation water, low leaching losses and high fertilizer uptake efficiency of sugarcane when irrigation water was applied in the rootzone in adequate quantity. The biwall drip irrigation technology has thus proved to be the effective and efficient means of saving expenditure on fertilizers for sugarcane crop without having reduction in its productivity.

5.11.3 Per hectare productivity improvement in sugarcane

The beneficial effect of biwall drip irrigation method was of increase in the per hectare output of

sugarcane. The details of increase in per hectare output of sugarcane due to adoption of biwall drip irrigation method are given in Table 23.

Table 23. The details of per hectare increase in yield of sugarcane by biwall drip irrigation method on sample farms

(Tonnes)

| Particulars | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|
| | Low | Medium | High | |
| 1. Per hectare output of sugarcane before drip irrigation | 89.48 | 90.00 | 93.32 | 91.14 |
| 2. Per hectare output of sugarcane after drip irrigation | 87.88 | 110.10 | 141.00 | 115.46 |
| 3. Difference in output per hectare | -1.60 (-1.79) | 20.10 (22.33) | 47.68 (51.09) | 24.32 (26.68) |

(Figures in parentheses indicate percentage increase in per hectare output of sugarcane due to biwall drip irrigation method).

At the overall level, the per hectare output of sugarcane was 91.14 tonnes when grown under surface irrigation method. On adoption of biwall drip irrigation method, the per hectare output of sugarcane increased to 115.46 tonnes. Thus, the productivity improvement of sugarcane when grown under biwall drip irrigation method was to the extent of 24.32 tonnes per hectare.

The phenomenon of productivity improvement of sugarcane due to adoption of biwall drip irrigation technology was observed only in the case of the medium and high sugarcane productivity groups of farms. The output of sugarcane increased by 20.10 and 47.68 tonnes per hectare, respectively, on the medium and high sugarcane productivity groups of farms. Contrary to this, the output of sugarcane on the low sugarcane productivity group farms decreased by 1.60 tonnes per hectare on adoption of biwall drip irrigation method. This has really been the matter of great concern as it reflects inefficiency on the part of management in managing irrigation water distribution programme effectively. The farmers belonging to the low sugarcane productivity group of farms reported that they could not get sufficient quantity of irrigation water to irrigate the crop because of the fact that the management favoured some of the well to do and influencing farmers in allocating additional irrigation water. This practice of discrimination in distributing irrigation water among the farmers coupled with ignorance on the part of some of the farmers in combining fertilizer and other inputs with irrigation water in adequate quantities have detrimental effect on sugarcane productivity. Corrective measures are, therefore, required in order to make this high-cost, high-tech irrigation system a grand success.

Plate-3 : Biwall drip irrigation unit

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Plate-4 : Biwall drip irrigation method for sugarcane

## 5.12 Total Receipts of the Lift Irrigation Scheme and Biwall Drip Irrigation Unit

The lift irrigation scheme and biwall drip irrigation unit received the revenue mainly from irrigation charges. Irrigation water was supplied to the cultivators in the command of the lift irrigation scheme to irrigate sugarcane and other perennial and seasonal crop by surface method and only to sugarcane and perennial fruit crops by biwall drip irrigation method and the water charges were collected from the cultivators. The management could meet the expenses on account of operating costs of the lift irrigation scheme/biwall drip irrigation unit through the receipts realised through collection of water charges. The details of the receipts, operating costs, net returns, additional benefits, additional costs and benefit-cost ratio of the lift irrigation scheme and biwall drip irrigation unit are presented in Table 24.

As discussed earlier, irrigation water was made available from lift irrigation scheme to irrigate seasonal crops on 93.60 hectares of land and perennial crops on 63.20 hectares of land of which the area under sugarcane was 48.00 hectares. The water charges for irrigating these crops by surface method were collected at the rate of Rs. 500.00 per hectare for the seasonal crops and Rs. 3000.00 per hectare for the perennial crops. On

Table 24. Details of annual receipts and costs of the lift irrigation scheme and biwall drip irrigation unit

| Particulars | Lift irrigation scheme | Biwall drip irrigation unit |
|---|---|---|
| 1. Area coverage (ha) | | |
| a) Seasonal crops | 93.60 | - |
| b) Sugarcane | 48.00 | 148.00 |
| c) Perennial crops | 15.20 | 29.20 |
| 2. Rate of irrigation water charges per hectare (Rs.) | | |
| a) Seasonal crops | 500.00 | - |
| b) Sugarcane and perennial crops | 3000.00 | 5000.00 |
| 3. Receipts from irrigation charges during 18 months (Rs.) | | |
| a) Seasonal crops | 46800.00 | - |
| b) Perennial crops | 189600.00 | 886000.00 |
| 4. Total receipts (Rs.) | 236400.00 | 886000.00 |
| 5. Total annual receipts (Rs.) | 157600.00 | 590666.00 |
| 6. Total annual operating cost (Rs.) | 378593.00 | 765927.00 |
| 7. Net returns | -220993.00 | -175261.00 |
| 8. Net additional benefit (Rs.) | 45732.00 | |
| 9. Additional annual benefits (Rs.) | 433066.00 | |
| 10. Additional annual costs (Rs.) | 387334.00 | |
| 11. Benefit-cost ratio | 1.12 | |

installation of biwall drip irrigation unit in the command, irrigation water was made available through biwall drip irrigation system exclusively for irrigating sugarcane crop and other perennial crops, and the water charges were collected at the rate of Rs. 5000.00 per hectare. The supply of irrigation water to sugarcane crop extended over the period of almost 17 to 18 months, the total receipts realised by the management during this period amounted to Rs. 236400 (composed of Rs. 46800 from seasonal crops and Rs. 189601 from sugarcane and perennial crops) and Rs. 886000 from the lift irrigation scheme and biwall drip irrigation unit, respectively. On annual basis, the total receipts from water charges worked out to Rs. 157600 and Rs. 590666 for the lift irrigation scheme and biwall drip irrigation unit, respectively.

The analysis relative to the operating cost of the lift irrigation scheme and biwall drip irrigation unit has shown that the total operating cost of the respective units worked out to Rs. 378593 and Rs. 765927 per annum. The comparison of the annual receipts and annual operating costs indicates that the lift irrigation scheme sustained the loss of Rs. 220993 per annuam. The biwall drip irrigation unit also sustained the loss of Rs. 175261 per annum. Thus, because of installation of biwall drip irrigation unit in the command, the net additional benefit to the

entire unit worked out to Rs. 45732. The entire unit can increase its net benefit and become a self-relient one by way of increasing the area under drip irrigation. This is possible because, the overhead cost remaining the same, the increase in the area under drip irrigation would result into lowering down the per hectare overhead cost of the entire unit. At present, the biwall drip irrigation unit is operating only for 5 to 6 hours per day. There is, therefore, the potential for irrigating additional area under the biwall drip irrigation unit. Based on the estimates of the additional annual benefits and additional annual costs, the benefit-cost ratio for the existing unit was calculated and it worked out to be 1.12.

5.13 Water Saving by Biwall Drip Irrigation Unit

The irrigation water use practice adopted by the sugarcane cultivators in the command of the lift irrigation scheme was similar to the one that practised by the farmers elsewhere in the irrigation project/lift irrigation project command areas in the State. In general, farmers have been using excessive water to irrigate sugarcane crop because of which there are the problems of wastage of water through deep percolation and seepage, development of water-logging conditions and lowering down soil fertility because of development of soil salinity and alkalinity conditions. These problems associated with the

surface irrigation method could be avoided only through the practice of applying limited water to irrigate the crop based on its water intake requirement. The biwall drip irrigation unit has been considered to be the most appropriate solution in this regard as it enables the producers apply limited irrigation water to the crop as per its requirement, and thereby it saves the water to a considerable extent. An additional attempt was, therefore, made to estimate the saving of irrigation water for sugarcane crop through adoption of biwall drip irrigation system. For this purpose, the total requirement of irrigation water for sugarcane crop grown under surface irrigation method and biwall drip irrigation method has been worked out separately at the system level and the details of the same are given in Table 25.

It could be revealed from the table that prior to installation of drip irrigation unit, the lift irrigation scheme worked for 9720 hours during the period of 18 months and irrigated the area of 156.80 hectares with the hourly discharge of 8.136 lakh litres of water. The total discharge of water during 18 months worked out to be 79081.92 lakh litres. Out of this, the allocation of water for sugarcane was 52944.68 lakh litres. Thus, the per hectare irrigation water requirement of sugarcane crop worked out to 837.73 lakh litres by surface irrigation method during its life period.

Table 25. Details of per hectare irrigation water saving due to adoption of biwall drip irrigation method for sugarcane

| | | | |
|---|---|---|---|
| A. | Particulars for cooperative lift irrigation scheme | | |
| | 1. Total irrigated area (In terms of water requirement of crop during 18 months) | | |
| | a) For sugarcane | = | 63.20 hectares |
| | b) For other crops | = | 93.60 hectares |
| | Total | = | 156.80 hectares |
| | 2. Total operational hours during sugarcane crop season of 18 months | = | 9720 hrs |
| | 3. Per hour discharge of water | = | 8.136 lakh lits |
| | 4. Total discharge of water during 18 months | = | 9720 X 8.136 |
| | | = | 79081.92 lakh lits |
| | 5. a) Water allocation for sugarcane | = | 52944.68 lakh lits |
| | b) Water allocation for other crops | = | 26137.25 lakh lits |
| | 6. Per hectare water for sugarcane | = | 837.73 lakh lits |
| B. | Particulars for biwall drip irrigation unit | | |
| | 1. Total irrigated area | | |
| | a) For sugarcane | = | 148 hectares |
| | b) For other crops | = | 29.20 hectares |
| | 2. Total operational hours during sugarcane crop season of 18 months | = | 2160 hrs |
| | 3. Total discharge of water during 18 months | = | 55944 lakh lits |
| | 4. a) Water allocation for sugarcane | = | 55944 lakh lits |
| | b) Water allocation for other crops | = | 29.2 X 378 |
| | | = | 11037.6 lakh lits |
| | 5. Per hectare water for sugarcane | = | 378.00 lakh lits |
| C. | 1. Water saving | = | 837.73 - 378 |
| | | = | 459.73 lakh lits |
| | 2. Water saving in percentage | = | 54.88 |

Contrary to the above, the lift irrigation unit worked only for 2160 hours to irrigate 148 hectares of sugarcane crop and 29.20 hectares of other perennial crops under biwall drip irrigation system. The total discharge of water through biwall drip irrigation unit worked out to 55944 lakh litres to irrigate 148 hectares of sugarcane area, and for other crops 11037.6 lakh litres by biwall drip irrigation method during the period of 18 months. Thus, the per hectare water requirement of sugarcane crop worked out to 378.00 lakh litres under the biwall drip irrigation method. The irrigation water saving worked out to 459.73 lakh litres per hectare. Thus, the water saving was as much as 54.88 per cent because of adoption of biwall drip irrigation system for sugarcane crop in the area.

## 5.14 Farm Level Benefits of Biwall Drip Irrigation Method

From the foregoing discussion, it is clear that the biwall drip irrigation unit has resulted into water saving, labour saving, fertilizer saving, and yield increase of sugarcane at the farm level. It being the high-tech capital intensive method of irrigation, there has been excessively additional investment in order to install drip irrigation unit in the command of the lift irrigation scheme. As mentioned earlier, these additional costs have been shared partly by the sugarcane grower's and partly by

the sugar factory after removal of subsidy component. The benefits realised by the sugarcane growers in terms of labour saving, fertilizer saving and yield increase are, in effect, the resultant outcome of the additional costs incurred by the farmers on account of contributing their share to the total investment cost of the drip irrigation unit. It was, therefore, thought more appropriate to compare the additional benefits of drip irrigation unit with the additional cost incurred by sugarcane growers on account of biwall drip irrigation unit at the farm level. Table 26 presents the details of the per hectare additional production cost, additional yield, additional total income and net additional returns on account of adoption of biwall drip irrigation method for sugarcane on the low, medium, high and overall sugarcane productivity groups of farms.

The critical examination of the figures given in Table 26 reveals that the per hectare additional output and total return from sugarcane crop grown under biwall drip irrigation method were 24.32 tonnes and Rs. 13989.19 over and above that of the sugarcane crop grown under surface irrigation method. As against this, the additional cost in sugarcane production cost due to adoption of biwall drip irrigation unit was to the extent of Rs. 12354.53 per hectare. The sugarcane growers could realise additional

Table 26. Per hectare additional costs and additional revenue from sugarcane due to adoption of biwall drip irrigation method

| | Particulars | Sugarcane productivity groups | | | Overall |
|---|---|---|---|---|---|
| | | Low | Medium | High | |
| 1. | Per hectare production cost of sugarcane (Rs.) | | | | |
| | a) Surface irrigation | 28101.53 | 23204.54 | 24662.85 | 25010.97 |
| | b) Biwall drip irrigation | 36636.11 | 34532.69 | 39818.86 | 37365.50 |
| | Additional cost | 8534.58 | 11328.15 | 15156.01 | 12354.53 |
| 2. | Per hectare total output of sugarcane (Tonnes) | | | | |
| | a) Surface irrigation | 89.48 | 90.00 | 93.32 | 91.14 |
| | b) Biwall drip irrigation | 87.88 | 110.10 | 141.00 | 115.46 |
| | Additional yield | - 1.60 | 20.10 | 47.68 | 24.32 |
| 3. | Per hectare total value of output of sugarcane (Rs.) | | | | |
| | a) Surface irrigation | 28103.27 | 27983.01 | 30543.03 | 28892.61 |
| | b) Biwall drip irrigation | 33385.30 | 40535.00 | 51555.30 | 42881.80 |
| | Additional total revenue | 5282.03 | 12551.99 | 21012.27 | 13989.19 |
| 4. | Per hectare net additional returns from biwall drip irrigation method (Rs.) | -3252.55 | 1223.84 | 5856.26 | 1634.66 |
| 5. | Benefit-cost ratio (Additional net returns ÷ Additional production cost) | 0.62 | 1.11 | 1.39 | 1.13 |

net return of Rs. 1634.66 per hectare due to adoption of biwall drip irrigation method. There was, however, no uniformity with regard to the net returns of biwall drip irrigation technology among the farms belonging to different sugarcane productivity groups. In the case of the medium and high sugarcane productivity groups of farms, the net additional return worked out to Rs. 1223.84 and Rs. 5856.26 per hectare, respectively. Contrary to this, the low sugarcane productivity group of farms sustained a net loss of Rs. 3252.55 per hectare because of adoption of biwall drip irrigation method for sugarcane crop on their farms. An attempt has, therefore, been made for calculating benefit-cost ratio for sugarcane productivity groups of farms. At the overall level, the benefit-cost ratio worked out to 1.13, while for the low, medium and high sugarcane productivity groups of farms, the benefit-cost ratios came to 0.62, 1.11 and 1.39, respectively.

## 5.15 Benefit-Cost Ratio and Rate of Return Analysis

The benefit-cost ratio for any project indicates us whether or not the costs of the project are fully recovered from the benefits. Therefore, the benefit-cost ratio for the biwall drip irrigation unit was calculated by using the following formula :

$$\text{Benefit-Cost ratio} = \frac{\text{Net additional annual benefit}}{\text{Interest on fixed capital investment} + \text{Annual working cost} + \text{Annual depreciation}}$$

Furthermore, an attempt has been made to estimate the benefit_cost ratio for the entire system by way of pooling together the farmer level and biwall drip irrigation unit level additional costs and additional benefits of the system as shown in Table 27.

Table 27. Benefit-cost ratio for the entire system

| | Particulars | Farmer level costs/benefits | System level costs/benefits | Total |
|---|---|---|---|---|
| 1. | Additional costs (Rs.) | 2189223 | 387374 | 2576557 |
| 2. | Additional net returns (Rs.) | 2478885 | 433066 | 2911951 |
| 3. | Benefit-cost ratio | $\frac{2911951}{2576557} = 1.13$ | | |

Thus, for the biwall drip irrigation system as a whole, the benefit-cost ratio worked out to 1.13.

The rate of return for the biwall drip irrigation unit was calculated by the formula,

$$i = \frac{B - C - K/n}{K} \times 100$$

where,

i = Rate of return on capital investment in per cent

B = Total annual benefits

C = Annual operating costs

K = Gross capital investment

n = Life of biwall drip irrigation unit in years

The rate of return for the biwall drip irrigation unit has been estimated as 30.73 per cent.

## 5.16 Projections of Operating Costs and Benefits of the Biwall Drip Irrigation Unit Using Saved Water

The foregoing discussion revealed that the existing biwall drip irrigation system for sugarcane was beneficial to the farmers and the sugar factory as well in some respects. The comparison of annual receipts and annual operating costs of lift irrigation scheme and biwall drip irrigation unit, however, indicated that the biwall drip irrigation unit sustained a loss. The entire biwall drip irrigation unit can avoid this loss and become a self-reliant one by increasing the area under biwall drip irrigation. This is possible by using saved irrigation water. An attempt was, therefore, made to find out the additional area that could be irrigated by saved water along with additional investment and operating costs and benefits for the farmers and the system as a whole.

The details of the additional investment costs, operating costs, total receipts, net additional benefit and benefit-cost ratios for the proposed additional area under sugarcane to be irrigated by biwall drip irrigation unit are given in Table 28.

The total quantity of saved water was 12125 lakh litres. With this additional irrigation water, it will be

possible to irrigate 32 hectares of land under sugarcane crop. If we assume that the additional area to be irrigated (32 hectares) is presently under rainfed crops and the same is to be brought under sugarcane cultivation with biwall drip irrigation method, the additional investment cost will amount to Rs. 190000 to the sugar factory and Rs. 188000 to the participating farmers. Thus, additional total investment cost will be Rs. 378000. The additional annual operating cost on account of the proposed expansion plan will amount to Rs. 589576 composed of Rs. 83000 as the annual operating cost for sugar factory and Rs. 56400 as the biwall drip irrigation unit annual operating cost and Rs. 450176 as the additional production cost of sugarcane to the farmers. On the other hand, the proposed expansion plan will yield additional annual receipts of Rs. 106667 to the sugar factory and Rs. 694667 to the farmers. When the additional operating cost is substracted from the additional total receipts, the proposed expansion plan is expected to yield net additional benefits of Rs. 23667 to the sugar factory and Rs. 188091 to the farmers. With the additional operating cost of Rs. 589576 and additional annual receipts of Rs. 801334, the benefit-cost ratio of the proposed expansion plan works out to 1.36.

Table 28. Projections of operating costs and benefits of the biwall drip irrigation unit using saved water

| | Particulars | Quantity |
|---|---|---|
| 1. | Total quantity of water saved (lakh lits) | 12125 |
| 2. | Additional area that could be irrigated with saved water (ha) | 32 |
| 3. | Additional investment cost for expanding biwall drip irrigation unit (net of subsidty) | |
| | (a) for sugar factory (Rs.) | 190000 |
| | (b) for farmers (Rs.) | 188000 |
| | Total | 378000 |
| 4. | Additional annual operating cost (Rs.) | |
| | (a) for sugar factory (Rs.) | 83000 |
| | (b) for farmers | |
| | (i) Biwall cost | 56400 |
| | (ii) Crop production cost | 450176 |
| | Total | 589576 |
| 5. | Additional total annual receipts (Rs.) | |
| | (a) To sugar factory | 106667 |
| | (b) To farmers | 694667 |
| | Total | 801334 |
| 6. | Additional net benefit (Rs.) | |
| | (a) To sugar factory | 23667 |
| | (b) To farmers | 188091 |
| | Total | 211758 |

Table 28 (Contd....)

| Particulars | Quantity |
|---|---|
| 7. Ratio of the additional benefits and additional costs | 1.36 |
| 8. Estimated total annual benefits for the system as a whole on using entire saved water (Rs.) | |
| (a) for 177.20 hectares | 2911951 |
| (b) for 32 hectares | 801334 |
| Total | 3713285 |
| 9. Estimated total annual cost for the system as a whole on using entire saved irrigation water (Rs.) | |
| (a) for 177.20 hectares | 2576557 |
| (b) for 32 hectares | 589576 |
| Total | 3166133 |
| 10. Estimated Benefit-Cost ratio for the system as a whole on using entire saved irrigation water | 1.17 |

It has been observed that the annual benefits and annual operating cost of the existing biwall drip irrigation unit amount to Rs. 2911951 and Rs. 2576557, respectively. If we add the annual benefits and annual costs of the proposed expansion plan to those of the existing annual benefits and annual costs, the benefit-cost ratio for the biwall drip irrigation unit using the entire saved irrigation water works out to 1.17. Besides, the internal rate of return for the biwall drip irrigation unit as a whole using the entire saved irrigation water will be 36.02 per cent.

## 5.17 Opinions and Suggestions of Sample Farmers About Biwall Drip Irrigation Method for Sugarcane

The opinions of the farmers on various aspects of the biwall drip irrigation method for sugarcane viz., benefits of biwall method, shortcomings in the method and utility of the biwall drip irrigation method as well as their suggestions for effecting further improvements in the biwall drip irrigation method for its efficient and effective functioning were obtained from the sample farmers. While confirming the benefits of the biwall drip irrigation method, majority of the participating farmers opined that the benefits were of multifarious type. They were able to derive tangible benefits if they possessed proper knowledge for operating the biwall drip irrigation unit. The benefits of the biwall drip irrigation system quoted by the farmers were in terms of saving of water to the extent of 40 to 50 per cent, and saving of fertilizers to the extent of 20 to 25 per cent as the part of urea was applied through water. The farmers experienced that because of proper application and use of irrigation water through biwall drip irrigation method, the requirement of labour for irrigation and inter-culturing operations reduced to a greater extent. In effect, labour saving has been considered to be one of the major benefits of the biwall drip irrigation method as there is acute shortage of labour in the area. The farmers belonging to medium and high sugarcane productivity groups of farms

opined that they could get 15 to 20 per cent increase in yield of sugarcane by using biwall drip irrigation method.

The farmers belonging to the low sugarcane productivity group of farms, however, expressed bitter experiences with the biwall drip irrigation method. They told that the decrease in yield of sugarcane was mainly because of inefficiencies in irrigation water distribution system and ineffective operation, maintenance, and repair (OMR) services. According to them, the system was ineffective because of choking of pipes and damages to the pipes caused by rats and men while performing different cultural operations.

The sample farmers made several suggestions for improving the efficiency and effectiveness of the biwall drip irrigation method. Some of the prominent suggestions are as under :

(1) The participating farmers be trained about the mechanism, maintenance precautions and repairing practices of biwall drip irrigation system at the field level so as to enable them to participate in the proper maintenance of the system to the extent possible.

(2) The efficiency of the operation, maintenance and repair services be improved immediately for enhancing overall efficiency of the entire system.

(3) The irrigation water be distributed equitably among all the participating farmers by way of adopting effective rotation system. The defects in the system be removed wherever necessary to maintain proper pressure to distribute water at the root zone of the crop throughout the field at constant rate.

(4) There has been saving of irrigation water because of adoption of biwall drip irrigation system. The farmers suggested that the irrigation water thus saved be allocated to them to bring additional area under irrigation.

(5) The management should take up the work of chemical analysis of soil and water and allocate water to sugarcane crop according to soil pH, soil type and electro-conductivity of soil so as to improve soil-plant-water relationship to a higher level.

## 5.18 Opinions of Management Regarding the Lift Irrigation Scheme and Biwall Drip Irrigation Unit

The work efficiency and responsibility of the management body (i.e. lift irrigation division of the sugar factory) have undergone some changes consequent upon installation of biwall drip irrigation system on the existing lift irrigation scheme. The experiences and suggestions of the management in this regard are mentioned below :

In the view of the management, the biwall drip irrigation system is relatively more efficient and effective in

irrigating sugarcane crop as compared to the earlier method of irrigating the crop with lift irrigation. It was possible to apply the optimum quantity of water for the crop. The new technology is, however, more expensive because of huge amount of capital investment. The management body expressed that the benefits derived from the biwall drip irrigation system are of multifarious type, the prominent ones among them being saving of water, application of water in the root zone of the crop, avoiding the ill effects of excessive water application, reduction in the cost on account of water lifting and fertilizer application, increase in crop productivity, etc.

The following suggestions have been made by the management body from the view point of planning for future strategy to popularise biwall drip irrigation method in the area.

(1) The management be allowed to lift saved amount of irrigation water and allocate the same among the farmers to irrigate additional area by drip irrigation method.

(2) Low cost technology be developed to manufacture different components of drip irrigation unit at cheaper cost.

(3) The quality of various components of biwall drip irrigation unit be maintained as per standardized norms so as to minimise OMR expenses in the future.

(4) To be able to implement this new technology, government should make available adequate funds to the sugar factories to enable them install biwall drip irrigation units in the command of the existing lift irrigation schemes in their jurisdiction.

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# Summary and Conclusions

# 6. SUMMARY AND CONCLUSIONS

Among the various inputs required for crop production, water is the most important and basic input besides land for growing crops. Also, water is the vital need of a man for his various activities. If water is not controlled and managed properly, water creates problems such as flood hazards, soil quality deterioration, ill health, environmental degradation, etc., which are of serious nature in respect of living conditions of the people and natural resource conservation. In India, agriculture as the major occupation has been rendered hazardous periodically by scarcity of rainfall in large areas and eratic monsoon elsewhere. Efforts have been made for supplying water artificially to the parched fields through development of irrigation water resources. Irrigation helps the farmers greatly by lessening risk in growing a crop and thereby increasing the average yields.

In effect, irrigation is the key input to increase agricultural production in virtually all of India. The available empirical evidence reveals that near about 40 per cent of irrigation potential has remained to be exploited as yet at the national level. Due to the inefficient irrigation water management practices at the various levels, the problems like waterlogging, soil quality deterioration and land and environmental degradation have become major obstacles in enhancing crop output. Owing to limitation

on availability of irrigation water, there is tendency among the farmers of diverting available water resources in favour of high pay-off crops and also using water by illegal means. The losses of water are also through conveyance, evaporation, percolation and seepage by using traditional methods of irrigation.

Among the cash crops grown in Maharashtra, sugarcane is the most important crop sharing about 3.83 lakh hectares of gross cropped area and nearly 80 per cent of the total irrigation water resources of the State. The sugarcane production in Maharashtra has been characterized by decline in productivity per unit of land and irrigation water resources because of low irrigation water supplies to the crop in some areas and due to excessive use of irrigation in certain other areas where the problems like waterlogging, declining productivity of soil and production have been observed. The traditional flow method of irrigating sugarcane is characterised by uneven distributioh of water which results in poor yields. Over irrigation results into gradual built-up of waterlogging and progressive built-up of salinity making soils unsuitable for cultivation. Due to inefficient irrigation water management practices at the system and farm levels, the productivity of sugarcane has been declining.

In this context, the technology of applying water

to rootzone area of sugarcane through biwall drip irrigation system seems to be advantageous to the farmers. The advantages of biwall drip irrigation technology in terms of having control over optimum combinations of irrigation water with other yield increasing inputs and saving water to bring additional cropped area under irrigation have been admired by a large number of farmers. The other advantages of biwall drip irrigation technology include reduced soil erosion, minimal weed growth, decreased water losses through transpiration, labour saving for inter-culturing and plant protection operations, saving of fertilizers and minimal incidence of pests and diseases. It is possible to obtain better yields and quality products with the use of biwall drip irrigation method.

Recently a large scale biwall drip irrigation unit has been established in Ankalkhop village of Tasgaon Tahsil in Sangli district at the auspices of Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli. This unit has been established on the existing cooperative lift irrigation project on about 177.20 hectares of land. The study on "Economic Efficiency of Drip Irrigation in Sugarcane Production in the Command of the Cooperative Lift Irrigation Project in Sangli District" was undertaken with the following objectives :

(1) To estimate investment and operating costs of

drip irrigation in the command of the cooperative lift irrigation project,

(2) To study relative economics of sugarcane production with drip irrigation and surface irrigation methods in the command of cooperative lift irrigation project, and

(3) To assess economic benefits and judge economic efficiency of drip irrigation unit in the command of the cooperative lift irrigation project.

The study was based on the micro level data relating to various aspects of the use of drip irrigation in sugarcane production on the farms in the command of the cooperative lift irrigation project in Ankalkhop village of Sangli district for the years 1987-88 and 1989-90. The farm level information on various aspects of capital investment and resource use structure, production costs, output, gross returns and net returns of sugarcane and other crops grown on the farms of the participating farmers was obtained from the sample of 90 sugarcane growing farmers in the command of the lift irrigation scheme at two points of time i.e. before and after installation of biwall drip irrigation unit. The sample of 90 sugarcane farms (with biwall drip irrigation unit) was equally divided into 3 sugarcane productivity groups viz., low, medium and high with the sugarcane productivity as 75 to 100 tonnes, 101 to 125 tonnes and 126 tonnes and above per hectare, respectively.

The data on various aspects of sugarcane production with and without biwall drip irrigation technology were obtained from the sample farms by survey method through personal interview with the help of a questionnaire specially designed for the purpose. Similarly, the data on total investment costs and operating costs of lift irrigation scheme and biwall drip irrigation unit were obtained through personal interview and the records available with the office of the concerned project.

The data thus collected were compiled and analysed statistically in order to obtain estimates of additional costs and additional returns of biwall drip irrigation technology in sugarcane production both at the farm level and the lift irrigation project level as well. The relative efficiency of biwall drip irrigation and traditional surface irrigation method was studied through benefit-cost analysis and rate of return of biwall unit vis-a-vis lift irrigation scheme. Benefit-cost analysis was attempted at the farmers' level, at biwall drip irrigation unit level and for the entire system level.

## 6.1 Summary of the Findings

The findings of the study have been summarized below.

(1) All the farmers who have been benefitted from the biwall drip irrigation system were the members of the

cooperative lift irrigation scheme. The average size of family was 4.92, at the overall level, and it varied within a narrow range among the different sugarcane productivity groups of farms. The composition of families differed slightly among the various sugarcane productivity groups of farms. About half of the family members were earners and the remaining dependents in all the sugarcane productivity groups of farms.

(2) The level of education of the family members increased as the size of family decreased. About 28.50 per cent, 11.55 per cent and 10.66 per cent of the members were illiterate in the low, medium and high sugarcane productivity groups of farms, respectively. The literacy percentage was low among the children.

(3) There was no specific relationship between the size of farm and productivity level of sugarcane. The distribution of small farms among different productivity levels of sugarcane was equal. A majority of the medium sized farms had low productivity level of sugarcane. In the case of the large sized farms, however, relatively a large number of farms had medium and high productivity levels of sugarcane.

(4) Among the farm families, the average size of holding was 1.48, 1.81, 1.94 hectares in respect of the low, medium and high sugarcane productivity groups of farms. About 95.43 per cent of the holding was under cultivation

before drip irrigation and 93.71 per cent holding was under cultivation after drip irrigation. The cropping intensity was 108.38 per cent and 101.22 per cent before and after drip irrigation, respectively. The cropping intensity was relatively higher in the medium sized sugarcane productivity group of farms than rest of the groups of farms.

(5) The average cropping pattern of the sample farms showed that, at the overall level, the area under sugarcane was 69.86 per cent of the gross cropped area before drip irrigation. It, however, increased to 82.53 per cent after drip irrigation. Out of this total area, the share of sugarcane with drip irrigation technology was 57.83 per cent and that of sugarcane with traditional irrigation method was 24.70 per cent. The area shares of kharif jowar, soybean, wheat, gram and grapes in the gross cropped area decreased by 1.25 to 5.50 per cent after introduction of biwall drip irrigation technology.

(6) The capital investment for lift irrigation scheme was Rs. 14.56 lakhs including the jack-well of Rs. 3.09 lakhs, intake well of Rs. 1.03 lakhs and pipe line system of Rs. 4.35 lakhs. The total investment cost for biwall drip irrigation unit was Rs. 56.27 lakhs composed of main pipe line of Rs. 5.02 lakhs, sub-main pipe line of Rs. 3.30 lakhs, lateral of Rs. 5.11 lakhs, biwall of Rs. 25.07 lakhs and electric motors of Rs. 4.53 lakhs. The investment in

other components was Rs. 11.00 lakhs. In the total investment cost of Rs. 56.27 lakhs, the loan from Sangli District Central Cooperative Bank was Rs. 21.77 lakhs, the contribution from Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli was Rs. 15.00 lakhs and the Government subsidy was Rs. 19.50 lakhs.

(7) The per farm total investment cost on account of biwall drip irrigation system amounted to Rs. 28750.54, Rs. 37190.31 and Rs. 43327.51 and the per hectare investment cost was Rs. 37122.42, Rs. 35532.14 and Rs. 41172.80 for low, medium and high sugarcane productivity groups of farms, respectively. At the overall level, the total investment cost in biwall drip irrigation unit was Rs. 36422.79 per farm and Rs. 38041.68 per hectare. The funds required for meeting investment cost were raised from the sources such as loan, sugar factory contribution and government subsidy. At the overall level, the relative contributions of loans from the Sangli District Central Cooperative Bank, funds from Vasantdada Shetkari Sahakari Sakhar Karkhana Ltd., Sangli and government subsidy to the total funds required for meeting investment cost were 40.18, 26.64 and 33.18 per cent, respectively.

(8) The annual operating cost of lift irrigation scheme was Rs. 378593 composed of fixed cost of Rs. 199800 and variable cost of Rs. 178793. The annual operating cost of

biwall drip irrigation unit was Rs. 1325551 composed of Rs. 1036858 as fixed cost and Rs. 288693 as variable cost.

(9) The input use structure of sugarcane grown under surface irrigation and biwall drip irrigation methods revealed that, at the overall level, the per hectare men and women labour use levels declined from 124.90 days and 129.83 days for surface irrigation method to 67.12 days and 116.33 days, respectively, when grown under biwall drip irrigation method. The per hectare requirement of bullock labour declined slightly and that of tractor hours remained the same for the crops grown under surface irrigation method and biwall drip irrigation method. The labour intensity for sugarcane was more in low productivity group of farms than rest of the two groups. Under biwall drip irrigation method, the per hectare requirement of men labour, women labour and bullock labour for sugarcane crop declined by about 64 mandays, 20 woman days and 2.50 bullock pair days, respectively as compared to surface irrigation method, among the different sugarcane productivity groups of farms. The per hectare requirement of sugarcane setts was approximately 25600 setts before drip irrigation and 26686 setts after drip irrigation. The use levels of N, $P_2O_5$ and $K_2O$ for sugarcane were 650 kg, 469 kg and 367 kg per hectare, respectively, when grown under surface irrigation method before drip irrigation and 443 kg, 205 kg and

319 kg, respectively after adoption of drip irrigation method for the crop.

(10) At the overall level, the per hectare total cost of production of sugarcane before drip irrigation was Rs. 25010.97. The cost of production at Cost-A and Cost-B levels worked out to be Rs. 17333.33 and Rs. 24200.47 per hectare, respectively. The total cost of production of sugarcane grown under biwall drip irrigation method was Rs. 37365.50 per hectare. The per hectare cost of production at Cost-A and Cost-B levels worked out to Rs. 24455.19 and Rs. 36336.24, respectively. The per hectare total cost of production of sugarcane under biwall drip irrigation method for low, medium, and high sugarcane productivity groups of farms were Rs. 36636.11, 34532.69, and 39818.86, respectively.

(11) The per hectare output of sugarcane was 91.14 tonnes under surface irrigation method before installation of drip irrigation unit, at the overall level. As against this, the per hectare output of sugarcane was 115.46 tonnes when grown under biwall drip irrigation system. Thus, the difference in per hectare output of sugarcane grown under surface irrigation method and biwall drip irrigation method was a little over 24 tonnes. The per hectare output of sugarcane under biwall drip irrigation method on the low, medium and high sugarcane productivity groups of farms was observed as 87.88, 110.10, and 141.00 tonnes, respectively.

(12) In general, the per hectare use levels of most of the inputs were relatively higher for different crops (other than sugarcane) on the sample farms during the latter period. The per hectare production costs of all the crops turned out to be slightly higher for the crops which were grown after drip irrigation than those of the crops which were grown before drip irrigation. At the overall level, the per hectare yield levels of all the crops which were grown after biwall drip irrigation were higher by 8.39 to 15.40 per cent than those of the crops grown before drip irrigation, the lowest and the highest yield differences being for soybean and grape crops, respectively.

(13) The total receipts and operating cost analysis of the lift irrigation scheme and biwall drip irrigation unit showed that the area under irrigation for lift irrigation scheme was 93.60 hectares for seasonal crops and 63.20 hectares for perennial crops. The management of the lift irrigation scheme realized total receipts of Rs. 236400 through irrigation water charges during the period of 18 months. So the total receipts worked out to Rs. 157600 per annum as against the total annual operating cost of Rs. 378593. The lift irrigation scheme sustained a net loss of Rs. 220993 per annum. In the case of the biwall drip irrigation unit, the area under irrigation was 117.20 hectares of perennial crops and the total receipts were

Rs. 886000 during the period of 18 months. Thus, the total receipts worked out to Rs. 590666 per annum, whereas the total annual operating cost was Rs.765927. There was a net loss of Rs. 175261 per annum in the case of the biwall drip irrigation unit. The comparison of annual operating costs and annual receipts of the lift irrigation scheme and the biwall drip irrigation unit revealed that with the additional annual operating cost of Rs. 387334, the management could realize additional annual receipts of Rs. 433066 on installation of biwall drip irrigation unit. There was, thus, net benefit of Rs. 45732 per annum to the management because of adoption of biwall drip irrigation technology in the command of the lift irrigation scheme. The ratio of additional benefits and additional operating cost worked out as 1.12 for the biwall drip irrigation unit.

(14) The total irrigation water requirement of sugarcane worked out to 837.73 lakh litres per hectare during the period of 18 months when grown under surface irrigation method. With the adoption of biwall drip irrigation method, however, the total irrigation water requirement of sugarcane declined to 378.00 lakh litres. There was thus water saving for sugarcane to the extent of 54 per cent due to biwall drip irrigation technology.

(15) The comparison of production costs, output and total returns of sugarcane grown under surface irrigation

method and biwall drip irrigation method revealed that with additional production cost of Rs. 12354.53 per hectare, the participating farmer could obtain additional output of sugarcane to the extent of 24.32 tonnes and thereby realize additional returns of Rs. 13989.19 per hectare on account of adoption of biwall drip irrigation technology. Thus, the sugarcane grower could realize additional net return of Rs. 1634.66 per hectare due to adoption of biwall drip irrigation technology. There was no uniformity with regard to the net returns of biwall drip irrigation technology among the farms belonging to different sugarcane productivity groups. In the case of the medium and high sugarcane productivity groups of farms, the net additional returns worked out to Rs. 1223.84 and Rs. 5856.26 per hectare, respectively. Contrary to this, the low sugarcane productivity group of farms sustained a loss of Rs. 3252.55 per hectare because of adoption of biwall drip irrigation technology. At the overall level, the benefit-cost ratio of biwall drip irrigation method worked out as 1.13. Among the low, medium and high sugarcane productivity groups of farms, the benefit-cost ratio was 0.62, 1.11 and 1.39, respectively. If we pool together the additional benefits and additional costs realized by the management and the participating farmers due to installation of drip irrigation unit in the command of the lift irrigation scheme then the benefit-cost ratio for the system as a whole comes to 1.13 and the internal rate of return works out to 30.73 per cent.

(16) Majority of the participating farmers opined that the benefits derived from biwall drip irrigation method were of multifarious type. The benefits were in terms of saving of water, saving of manures and fertilizers, saving of labour and increase in yield. The farmers belonging to the low sugarcane productivity groups of farms expressed bitter experiences of decrease in yield because of inefficiencies in irrigation water distribution system and ineffective operation, maintenance and repair (OMR) services.

The participating farmers have suggested that they should be trained about the mechanism, maintenance precautions and repairing practices of biwall drip irrigation unit at the field level. Also, they suggested that the efficiency of OMR services be improved and irrigation water be distributed equally among all the farmers. Quite a good number of farmers suggested that the irrigation water which is saved due to adoption of biwall drip irrigation method should be lifted and allocated to the farmers according to soil conditions.

(17) In the opinion of the management, the biwall drip irrigation system is relatively more efficient and effective in irrigating sugarcane as compared to the earlier method of irrigation with lift irrigation scheme. The benefits included saving of water, application of water at root zone, avoiding ill effects of excessive use of water and reduction in cost of water lifting and fertilizer application.

The management suggested that it should be allowed to use saved water for irrigating additional area under drip irrigation method. The other suggestions included a need to evolve low cost biwall drip irrigation technology and improve quality of different components of biwall drip irrigation unit. The management expected the government to come forward to make available adequate funds for installation of new biwall drip irrigation units on a massive scale in the jurisdiction of the sugar factories in the State.

## 6.2 Conclusions

In the light of the empirical evidence brought out by the study, the following conclusions could be drawn.

(1) The farm families participating in the new venture of installation of biwall drip irrigation system in the command of the lift irrigation scheme have been characterized by a relatively small size of family and lower proportion of earners in the family. The literacy percentage and the level of education have had positive impact on the farm families in adoption of new technology. All these factors together ought to have motivated the farm families to adopt biwall drip irrigation system for sugarcane.

(2) There was no specific relationship between the size of the farm and productivity level of sugarcane. The large sized farms could afford to spend relatively more on different

inputs in order to realize high productivity of sugarcane as compared to the other size groups of farms.

(3) After adoption of drip irrigation technology, the proportion of cultivated area in the total area was reduced slightly, indicating thereby almost non-significant change in the land use pattern on introduction of drip irrigation technology. The total irrigated area, however, increased in each group after adoption of drip irrigation technology. The net cropped area declined marginally after drip irrigation mainly because of diversion of some area for construction of roads, buildings, etc. The gross irrigated area and gross cropped area were relatively higher in the case of the high sugarcane productivity group of farms as compared to the other two groups of farms. The cropping intensity decreased to some extent after drip irrigation. The irrigation intensity, however, decreased significantly because of increased area allocation to sugarcane crop after drip irrigation.

(4) The biwall drip irrigation system is a new and costlier technology. The farmers participating in this new venture of joint use of a large scale drip irrigation unit were dependent on loan for biwall set and subsidy from government. There was one interesting point that not a single farmer could effect the entire or partial investment from his own funds. All of them availed loan facilities

from Sangli District Central Cooperative Bank and sugar factory. The subsidy component proved to be the major incentive to the farmers to participate in the joint venture of adopting a highly capital intensive high-tech irrigation system on the farms.

(5) With the adoption of biwall drip irrigation system for irrigating sugarcane, the use levels of labour, manures and fertilizers reduced to a greater extent. There was saving of labour. The requirement of men labour under the new technology was observed to be lower than that of surface irrigation because there was saving of labour for irrigating the crop and fertilizer application. The weed growth was checked and labour requirement for interculturing reduced to a considerable extent. Along with the saving of labour, there was saving of fertilizers under biwall drip irrigation method mainly because of application of N through irrigation water, low leaching losses and high fertilizer uptake efficiency of sugarcane when irrigation water is applied at the root zone of the crop. Thus, there was saving of fertilizer cost without affecting sugarcane productivity.

(6) The beneficial effect of biwall drip irrigation system was the increase in the per hectare output of sugarcane. The productivity improvement of sugarcane grown under biwall drip system was to the extent of 24.32 tonnes per hectare. The phenomenon of increasing productivity was

observed in the medium and high sugarcane productivity groups of farms. In the case of the low productivity group of farms, the yield decreased due to the inefficiency on the part of management in managing the irrigation water distribution programme effectively.

(7) The cost of production of sugarcane under surface irrigation method was lesser than that of the crop grown under biwall drip irrigation method. The cost of production of sugarcane grown under biwall drip irrigation method was higher because of increased cost on account of depreciation on laterals and biwall pipes, interest on loan, increase in irrigation water charges, and rising prices of inputs.

(8) The adoption of biwall drip irrigation method for irrigating sugarcane crop did not affect the input use structure of other crops to any significant extent. In general, the per hectare use levels of most of the inputs for different crops was slightly high during the latter period. The crops showed increased yield levels and also increased returns because of slightly higher use levels of resources and increased output prices during the latter period.

(9) The adoption of biwall drip irrigation method in place of surface irrigation method for sugarcane crop in the command of the lift irrigation scheme has yielded net additional benefit of Rs. 45732 per annum. There is a

scope for increasing the benefits of biwall drip irrigation system in the command by way of increasing the area under drip irrigation with the use of saved water. At present, the biwall drip irrigation unit is operating only for 5 to 6 hours per day. That means, there is further scope for operating the system for more number of hours daily to irrigate additional area and thereby reducing the per unit operating cost. This is possible because the overhead cost remaining the same, the increase in the area under drip irrigation would result into lowering down the per hectare overhead cost of the entire unit.

(10) Based on the estimated quantities of irrigation water applied to sugarcane by surface irrigation method and biwall drip irrigation method, it was concluded that the irrigation water saving for sugarcane was to the extent of 459.73 lakh litres per hectare. Thus, the water saving was as much as 54.88 per cent because of adoption of biwall drip irrigation system for sugarcane crop in the area.

(11) Because of adoption of biwall drip irrigation method for sugarcane, the participating farmers could get net additional benefit of Rs. 1634.66 per hectare over and above the crop grown under surface irrigation method. At the overall level, the benefit-cost ratio of biwall drip irrigation method worked out to 1.13. The benefit-cost ratio for the entire system worked out to 1.13. Also, the

internal rate of return for the biwall drip irrigation unit was estimated as 30.73 per cent.

(12) In the opinion of the participating farmers and the management, the biwall drip irrigation method for sugarcane was a very useful and beneficial system. It proved to be profitable to the farmers and the management as well. The benefits such as water saving, fertilizer and manure saving, increased productivity of sugarcane, avoiding ill effects of excess irrigation, saving cost of lifting water, etc., are of multifarious type. Indeed, the biwall drip irrigation technology could become an effective instrument for improving economic condition and social structure of the farmers. The deficiencies in implementing the biwall drip irrigation system, however, need to be removed immediately in order to make the biwall drip irrigation system more efficient and effective.

(13) The proposed expansion plan to irrigate additional area with the saved water is expected to yield net additional benefit of Rs. 23667 to the sugar factory and Rs. 188091 to the farmers. The benefit-cost ratio of the proposed expansion plan worked out to 1.36. If the saved irrigation water is used for irrigating the additional area, the benefit-cost ratio for the entire biwall drip irrigation system as a whole would work out to 1.17, while the internal rate of return will be 36.02 per cent.

In summary, the study concluded that the biwall drip irrigation system has become an important instrument for increasing crop production, improving economic condition, stabilizing the income, and improving overall condition of the farmers. The efforts aiming at removal of existing inefficiencies in the implementation of the biwall drip irrigation system for sugarcane would certainly fetch a good dividend to the participating farmers and management of biwall unit, and thereby the entire unit could become an ideal to the others.

## 6.3 Policy Implications

The success of biwall drip irrigation system for sugarcane depended entirely on the joint effort of the participating farmers, management of biwall drip irrigation unit and the government. The following measures could prove to be useful for the success of the biwall drip irrigation technology in other areas -

(1) To be able to implement this new technology on a wider scale, the government should make available adequate funds at the reasonable rate of interest to the farmers and various other agencies participating in the joint ventures of adopting high-tech and high-cost irrigation water use technology.

(2) The management should treat all the farmer members equally while distributing irrigation water through biwall drip irrigation unit.

(3) For successful implementation of the biwall drip irrigation system, the farmers should carry on all the farming operations in time and take appropriate care for effective maintenance of the system at the field level.

(4) The participating farmers be trained about the mechanism, maintenance precautions and repairing practices of biwall drip irrigation system at the field level so as to enable them participate in the proper maintenance of the system to the extent possible.

# Literature Cited

## 7. LITERATURE CITED


*Anonymous. 1945. Famine Enquiry Commission, New Delhi, Final Report, pp. 129.

Anonymous. 1980. Sugarcane Research at Padegaon. Central Sugarcane Research Station, Padegaon, M.P.K.V., Rahuri, p. 38-40.

Anonymous. 1986. Annual Progress Report (1980 to 1986). All India Coordinated Project for Research on Water Management, M.P.K.V., Rahuri, p. 1-100.

Apte, D.P. and Mulla, G.R. 1963. Comparative cost of lifting water from wells. Arthavijnana, 5(4):282-294.

*Aziz, M.H.A. 1971. Trickle irrigation in Kuwait. Department of Agriculture, State of Kuwait.

Bagi, F.S. 1981. Economics of irrigation in crop production in Haryana. Indian J. of Agril. Econ., 36(3): 15-26.

Baldota, S.B. and Bhatane, R.S. 1983. Evaluation of trickle irrigation system for brinjal. A design project report submitted to M.P.K.V., Rahuri.

Bangal, G.B., Khaire, R.S., Jadhav, S.B. and Umrani, N.K. 1987. Comparison of drip and check basin method of irrigation for pomegranate orchard. Drip and sprinkler irrigation methods. Adoption paper presented at National Seminar held at M.P.K.V., Rahuri in April, 1987. 637(1):127-131.

*Bisalish, S. 1984. Contribution of irrigation to output and employment growth under new wheat production technology. J. of Asian Econ. Review, 26(½):70.

Biswas, A.K. 1985. Monitoring and Evaluation of Irrigation Projects. ICID Bulletin, 34(1):12-18.

*Bowonder, B., Ramana, K.V., Ravi, C. and Srinivas, C. 1987. Land use, water logging and irrigation management. Land use policy-1987, 4(3):331-341.

Bresler, E. 1977. Trickle-drip irrigation. Principles and application to soil water management. Advances in Agronomy, 29:343-393.

Bryan, H.H. 1976. Drip irrigation takes seven legue strides. World Farming.

Bucks, D.A., Nakayama, F.S. and Gilbert, R.G. 1979. Trickle irrigation water quality and preventive maintenance. Agril. Water Management, 2(2):149-162.

Chapman, L.S. 1980. Sub-surface irrigation for the Australian Sugar Industry. International Sugar Journal, 82(975):71-74.

*Clerk, R.N. 1979. Furrow, sprinkler and drip irrigation efficiencies in corn. Proc. of ASAE, Paper No. 79: 2111:2.

*Combres, J.C., Bussire, F. and Bastergue, P. 1989. First trial of underground drip irrigation in sugarcane in Guadeloupe. Bull. Agronomique (Petit-Bourg), 9: 27-33.

Datten, S. and Haminson, P.E. 1971. Drip irrigation for citrus. Citrus and Vegetable Magazine, 34:8.

Deo, K.P. 1979. Economic evaluation of the lift irrigation schemes in Maharashtra. A Thesis submitted to Poona Univ. for Ph.D. degree.

Deshmukh, A.S., Gunjal, B.B., Shinde, P.P., Kamthe, S.D. and Hapse, D.G. 1988. A note on comparative performance of surface drip, sub-surface drip (biwall) and furrow method of irrigation for sugarcane (Var. Co. 7219). Techno-economic feasibility study of drip irrigation with special referenco to sugarcane. Oct. 1988, 40-41.

Deshmukh, M.T. 1989. Drip irrigation for coastal region. Symposium on drip irrigation held at M.P.K.V, Rahuri, p. 58-61.

Dhotrey, R.S. and Mane, T.A. 1988. Response of sugarcane to drip method of irrigation. A report on 24th Annual Convention. Indian Soc. of Agril. Engg., held at P.K.V., Akola, Sec. II : 9.

Dutta, D.K. 1987. Role of groundwater in the development of agriculture in India. Agril. Situation in India, 13(4):261-266.

*Gadgil, D.R. 1948. Economic effect of irrigation. Gokhale Institute of Politics and Economics, Pune.

Gete, R.M. 1993. Irrigation management for sugarcane. Godava, 29-30.

Gibson, W. 1978. Drip irrigation of sugarcane- The Hawaiin Story. International Sugar Journal, 80(960):362-366.

Godoy, G., Palacos, A. and Barrante, A. 1985. Sugarcane under drip irrigation in Venezuella. Drip-Trickle irrigation in action. Proc. Third Int. Drip/Trickle Irrigation Congress. Amer. Soc. of Agril. Engg., Michigan, 43348:133-138.

*Goldberg, D. and Sehumelli, M. 1969. Trickle irrigation- a method for increased agricultural production under conditions of saline water and adverse soils. Proc. of International Arid Lands Conference, Africa.

Gurjar, Ramkumar. 1990. Geographical perspectives on irrigation, Jaipur. Rawat Publications.

Gustafsan, C.D. 1971. Salinity and drip irrigation. Citograph, 66:31-33.

*Gutal, G.B., Chougule, A.A. and Jadhav, S.S. 1990. Irrigation scheduling for sugarcane through trickle system. In Proc. 11th International Congress on 'Use of Plastic in Agriculture', New Delhi.

Hall, B.J. 1982. Drip versus furrow stalking high yields. J. of Amer. Veg. Grower, 30(4):18-20.

Jadhav, S.B., Nigade, R.D. and Kadam, R.K. 1993. Micro-irrigation techniques in sugarcane agriculture. Bharatiya Sugar, 19(11):55-56.

Joshi, P.K. 1987. Effect of surface irrigation on land degradation problems and strategies. Indian J. of Agril. Econ. 42(3):416-423.

Kale, S. 1991. A note on drip irrigation. Godava, p. 55-56.

Kaul, S.N. 1974. 'On water use in India'. April, 1974. Margin, 6(2):146-156.

Khare, M.P. 1979. Growth of irrigation in Maharashtra. (1960-61 to 1971-72). Arthvijnana, 21(2):153-198.

*Knowles, 1943. Economic development of British Empire overseas. 1:367.

Kulkarni, A.A. 1988. Response of pomegranate and lime to trickle irrigation. M. Tech. Thesis (Agril. Engg.), submitted to M.P.K.V., Rahuri.

Kulkarni, A.A. and Suryawanshi, S.N. 1988. Evaluation of drip irrigation method for pomegranate. 24th Annual Convention, Indian Soc. of Agril. Engg., P.K.V., Akola, Sec. II, 10.

Londhe, R.B. and Kalbande, V.H. 1980. A design and evaluation of drip irrigation systems for tomato. Unpub. Thesis submitted to M.P.K.V., Rahuri.

Magar, S.S. 1985. Advanced irrigation water management technology for sugarcane under water resource constraints. The Deccan Sugar Technologists Association, Pt. I, 35th Annual Convention, p. A-15-A-19.

Mane, T.A. and Magar, S.S. 1983. Sugarcane response and water economy by adoption of drip irrigation system. Deccan Sugar Technologists Association (India), 33rd Annual Convention, 1993, Pt. I.

*Mannai, S.I. and Sallam, A.M. 1972. Evapotranspiration and irrigation requirements of some vegetable crops in relation to irrigation methods in Kuwait. A paper presented to 11th FAD Regional Conference in Kuwait.

Mellor, J.W., Weaver, T.F., Lele and Simon. 1968. In Developing Rural India- Plan and Practice. p. 41-47. Cornell University Press, 124 Robert Place, Ithaca, New York.

*Misra, S. 1968. A comparative study of the Economics of minor sources of irrigation in U.P. p. 112-115.

*Nemon, N., Huene, B., Von, H., Gallichand, J. and Broughton, R.S. 1987. Subsurface irrigation and drainage on sandy soil in Southern Quebac. Canadian Agril. Engg. (1987), 29(2):137-142.

*Orth, P.G. 1979. Developing guidelines for drip irrigation of row crops in shallow soils. J. Florida State Hort. Soc., 91:310-312.

Padmakumari, O. and Sivanappan, R.K. 1979. Economics of drip irrigation for water scarce regions. Madras agric. J., 66(7):486-490.

Paliwal, K.V. 1986. Saline water irrigation through drips and sprinklers. Annals of Arid Zone, 25(1):18-30.

*Patel, S.M. and Patel, K.V. 1969. Studies in the economics of rural electrification and lift irrigation. Abstract of research studies in management in agriculture. Indian Institute of Ahmedabad, Gujrath State, pp. 27.

Pathak, B.D. 1983. Development of groundwater resources for irrigation in India. Agril. Situation in India, 38(5).

Patil, S. 1988. Development of drip irrigation in India and Maharashtra, Godava, 12:13-20.

Patil, S.D. 1989. Drip is ideal for banana. Intensive agriculture, 27(3).

Patil, S.M. 1989. A note on result of yield of ratoon sugarcane by using drip irrigation and traditional methods. Godava, 8:1-5.

Pawade, M.N. 1989. Drip irrigation systems for citrus crop. Symposium on drip irrigation, M.P.K.V., Rahuri, 54:57.

Pawar, H.K., Shinde, S.H., Patil, B.R. and Magar, S.S. 1983. Studies on layout, earthing up and irrigation

schedule for adsali sugarcane Co 7219. Deccan Sugar Technologists Association, 33rd Annual Convention, Pt. I, A 79-A 84.

Pawar, J.R. 1970. Estimation of resource productivities of major inputs on a sample of sugarcane farms in Sangli district. Unpublished thesis submitted to M.P.K.V., Rahuri.

Pawar, L.G. and Bhosale, R.J. 1983. Studies on pre-monsoon irrigation requirements of sugarcane variety Co 740 under Dapoli conditions. Deccan Sugar Technologists Association, 33rd Annual Convention, Pt. I, A 45-A 52.

Peterson, D.F. 1987. Some Issues in Irrigation Macro-Strategies. Water International, 12(3):102-109.

Phirake, N.N. 1992. Biwall (Drip method) is useful for vegetable crops. Godava, Mar. 1992. p. 27-28.

*Ramlingam, C. 1963. Studies in the economics of farm management in Punjab. J. Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi, Government of India Publication.

Rangarajan, 1992. Better water management. Kisanworld, Mar. 1992, 19(3):

*Remdial, L. 1974. Some soil-plant-Moisture relationship of sugarcane plant. J.A.S.T. Journal, (35):77-87.

*Roth, R.L., Rodney, D.R. and Gardner, B.R. 1978. Comparison of irrigation methods, root stocks and fertilizer element on valencia orange trees. Proc. 2nd International Drip Irrigation Congress, U.S.A., 103-108.

*Sammis, T.W. and Hanson, E.G. 1975. Potato and lettuce response to irrigation methods and practices. A compilation of trickle irrigation, American Soc. of Agril. Engg., National Meeting, 78(20):1-11.

*Sammis, T.W. and Hanson, E.G. 1980. Potato and lettuce response to irrigation methods and practices. A compilation of trickle irrigation. Papers published by American Soc. of Agril. Engg., 34403, 631.7.

*Sandhu, D.S. 1981. Geography of sugarcane cultivation- A case study of Haryana. J. Vishal Publication, Kurukshetra, 52-53.

*Sankhayan, P.L. and Singh, I. 1985. Impact of surface and lift irrigation systems on the cropping pattern, income distribution and economic efficiency in Punjab. J. Econ. Affairs, 30(3):201-209.

Sengupta, N. 1985. Irrigation - Traditional versus Modern. Economic and Political Weekly (Nov. 85), 20(45, 46 & 47):1919-1938.

Shah, S.M. 1963. Cropping pattern in relation to irrigation. Indian J. of Agril. Econ., 18(1):154.

Shahane and Iyangar Rajan, M.K. 1954. A text book of irrigation published by Shri Sunderdas for Noble book service, New Rajendranagar, New Delhi.

Shan, L.L.P., Hardy, M. and Chan, P. 1977. Drip irrigation of sugarcane. In Proc. 16th Congress, International Soc. of Sugarcane Technologists (1977), 1219-1225. International Sugar Journal, 81:144.

Shanmugham, K., Meenakshi Sundaram, P.C. and Seshadri, V.C. 1976. Drip irrigation - An efficient technique. Indian Farming, 26(1):15-17.

Shih Sun, F. 1988. Drip irrigation and sub-irrigation of sugarcane. J. of Irrigation and Drainage Engineering, 114(1):143-155.

Shinde, A. 1982. Drip irrigation system. Godava, (5):7-8 and 15-17.

Singh, M.L. 1973. Trickle irrigation ensures higher water use efficiency. Indian Farming, 11:23-25.

*Singh, M.L. 1973. Economics of water for irrigation. Eastern Economist. (L x 7):293-295.

Singh, P.P., Saini, S.K., Kumar, K. and Negi, P.S. 1984. Studies on plant population and irrigation requirements of sugarcane under Tarai conditions of U.P. Indian Sugar, 34(8):621-624.

*Singh, R.K., Amir, D.S. and Lamia, K. 1981. Salt and water distribution in different trickle irrigation frequencies. J. Tech. Bull. (Under Publication), SOLR Republic of Iraq.

Singh, R.K., Suliman, A.D. and Lamia, K. 1989. Movement of salt and water under trickle irrigation and its field evaluation. J. of Agril. Engg. A.S.A.E., 26 (1):49-51.

Singh, S.D. and Singh, P. 1978. Value of drip irrigation compared with conventional irrigation for vegetable production in hot and arid climate. Agron. Journal 70(6).

Sinha, A.K. 1978. Impact of lift irrigation on cropping pattern and crop yields based on five village survey in Bhiwani. Indian J. of Agril. Econ., 33(1):77-92.

Sivanappan, R.K. 1977. Trickle irrigation for water scarcity areas. Agril. Engineers (India), 20:23-25.

Sivanappan, R.K. 1980. Drip irrigation. Tamil Nadu Agril. University, Coimbatore, S.V.N.P. Report, 87(15).

Sivanappan, R.K. 1989. Drip irrigation research development and potential in India. Symposium on drip irrigation by S.S. Magar.

Sivanappan, R.K. 1992. New irrigation strategies for the future. Kisanworld, 19(4):33-35.

Wayse, U.S. and Kulkarni, N.R. 1987. Evaluation of drip irrigation performance in farmers field for grapes in Sangli district - A case study. Drip and Sprinkler irrigation methods - Adoption papers presented at the National Seminar on I.F.D.I.W.M. held at Rahuri, 637.1:293-306.

Yadava, R.L. 1991. Sugarcane production technology constraints and potentialities. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Bombay, Calcutta, p. 175-176.

Yadava, R.L. 1991. Sugarcane production technology constraints and potentialities. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Bombay, Calcutta, pp. 197.

Zende, G.K. 1972. Irrigation requirements of sugarcane. Indian Farmers Digest, 5(10):33-34.

* Originals not seen.

# Appendices

# 8. APPENDICES

Topic of Research: Economic Efficiency of Drip Irrigation in Sugarcane Production in the Command of the Cooperative Lift Irrigation Project in Sangli District

## Appendix - I

## Questionnaire

A. FOR COOPERATIVE LIFT IRRIGATION AND DRIP IRRIGATION PROJECT

I. General information about the lift irrigation scheme

1. Name of the Scheme :
2. Year of establishment :
3. Command area of the Scheme :
4. Name of the river :
5. Village :
6. Tahsil :
7. District :

II. Information about members

| Sr. No. | Type of members | Number | Total land (ha) | Irrigated area (ha) |
|---|---|---|---|---|
| 1. | Marginal farmers (below 1 ha) | | | |
| 2. | Small farmers (1 to 2 ha) | | | |
| 3. | Medium farmers (2 to 4 ha) | | | |
| 4. | Large farmers (Above 4 ha) | | | |
| | Total | | | |

(App. I : Contd....)

III. Physical structures and itemwise costs of lift irrigation scheme

| Sr. No. | Particulars | Description | Year of purchase | Purchase price (Rs) | Present price (Rs) |
|---|---|---|---|---|---|
| 1. | Jack-well | | | | |
| 2. | Intake well | | | | |
| 3. | Sumpwell | | | | |
| 4. | Pumphouse | | | | |
| 5. | Pumping machinery | | | | |
| 6. | Pipe line system | | | | |
| | a) Intake pipe | | | | |
| | b) Rising main | | | | |
| | c) Gravity main | | | | |
| | d) Distributories (Coupling joints) | | | | |
| 7. | Delivery chamber | | | | |
| 8. | Office building | | | | |
| 9. | Staff residential buildings | | | | |
| 10. | Furniture | | | | |
| 11. | Others | | | | |

IV. Information about funds and loans for completion of scheme

| Sr. No. | Source | Amount (Rs.) | Interest rate (Rs.) | Annual instalments (Rs.) | No. of annual instalments & annual over dues |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. | | | | | |

(App. I : Contd...)

V. Details of annual operating and maintenance costs of lift irrigation scheme

| Sr. No. | Items of cost | Amount (Rs) |
|---|---|---|
| 1. | Staff salaries, wages and allowances. | |
| 2. | Recurring costs | |
| 3. | Repair and maintenance | |
| 4. | Elec. charges and water charges | |
| 5. | Office expenses | |
| 6. | Stationary and postage | |
| 7. | Insurance | |
| 8. | Inspection and audit fee | |
| 9. | Travelling expenses | |
| 10. | Other expenses | |

VI. Information on water charges.

a) What is the basis for water charges ?

Charges per hectare irrigated area or volume of water applied.

If charged on per hectare irrigated basis, please indicate the per hectare water charges

| Sr. No. | Season | Crops | Water charges per irrigated hectare (Rs.) |
|---|---|---|---|
| 1. | Kharif | | |
| 2. | Rabi | | |
| 3. | Summer | | |
| 4. | Annual | | |
| 5. | Perennial | | |
| | Total area irrigated (ha) | | |

VII. Information on total annual receipts of the scheme

| Sr. No. | Particulars | Amount (Rs.) |
|---|---|---|
| 1. | Total water charges to be received | |
| 2. | Actual amount of water charges to be received | |
| 3. | Total overdues on account of water charges | |
| 4. | Amount of water charges and overdues of previous years received | |
| 5. | Amount of penalty charges | |
| 6. | House rent collections from staff | |
| 7. | Any other receipts realised | |
| | Total | |

VIII. Physical structure and itemwise costs of drip irrigation unit

| Sr. No. | Particulars | Total length (m) | Number or size | Purchase year | Purchase price (Rs.) | Present price (Rs.) | Repair & maintenance expenditure (Rs.) | Remaining life (Yrs) |
|---|---|---|---|---|---|---|---|---|
| 1. | Main line | | | | | | | |
| 2. | Sub-main line | | | | | | | |
| 3. | Lateral line | | | | | | | |
| 4. | Ancillary components | | | | | | | |
| | a) Valve | | | | | | | |
| | b) Pressure regulator | | | | | | | |
| | c) Filters | | | | | | | |
| | d) Pressure guage | | | | | | | |
| | e) Fertilizer application components (tree, elbow, end base) | | | | | | | |

IX. Capital requirement for drip irrigation set

| Sr. No. | Total investment for drip irrigation set | Owned capital | Loan | | | | Subsidy | |
|---|---|---|---|---|---|---|---|---|
| | | | Source | Amount (Rs.) | Rate of interest (Rs.) | Repayment period (Years) | Percentage | Amount (Rs.) |
| 1. | | | | | | | | |
| 2. | | | | | | | | |
| 3. | | | | | | | | |
| 4. | | | | | | | | |
| 5. | | | | | | | | |
| 6. | | | | | | | | |

(App. I : Contd...)

(App. I : Contd....)

X. Details of annual operating and maintenance cost of drip irrigation unit

| Sr. No. | Items of costs | Units | | Amount (Rs.) |
|---|---|---|---|---|
| | | Number | Rate | |
| 1. | Staff salaries | | | |
| 2. | Recurring costs | | | |
| | a) Elec. bill | | | |
| | b) Repair and maintenance | | | |
| | 1. Repair of elec. motor | | | |
| | 2. Laterals | | | |
| | 3. Driper | | | |
| | 4. Microtubes | | | |
| | 5. Nozzle | | | |
| | 6. Filter paper | | | |
| | 7. Chemicals | | | |
| | 8. Oils | | | |
| | 9. Cleaning of laterals | | | |
| | c) Water charges | | | |
| | d) Office stationary, postage | | | |
| | e) Insurance | | | |
| | f) Inspection and audit fee | | | |
| | g) Travelling expenses | | | |

Returns : What is basis for water charges ? If water charges on per hectare irrigated area basis, then indicate water charges as

| Sr. No. | Season | Crop | Charges per ha (Rs.) |
|---|---|---|---|
| 1. | Kharif | | |
| 2. | Rabi | | |
| 3. | Summer | | |
| 4. | Annual | | |
| 5. | Perennial | | |

XI. Operational area under drip irrigation unit

| Sr. No. | Source | Total irrigated area (ha) | Additional irrigated area (ha) |
|---|---|---|---|
| 1. | Lift irrigation scheme | | |
| 2. | Drip irrigation unit | | |

(App. I : Contd....)

XII. Cropping pattern and average yields of crops under Lift Irrigation Scheme and Drip Irrigation Unit

| Sr. No. | Season | Crop | Area under (ha) | Average yield (q) |
|---|---|---|---|---|
| A. | Under Lift Irrigation | | | |
| 1. | Kharif | | | |
| 2. | Rabi | | | |
| 3. | Summer | | | |
| 4. | Annual | | | |
| 5. | Perennial | | | |
| B. | Under Drip irrigation | | | |
| 1. | Kharif | | | |
| 2. | Rabi | | | |
| 3. | Summer | | | |
| 4. | Annual | | | |
| 5. | Perennial | | | |

XIII. Saving of water in details in Lift Irrigation Scheme and Drip Irrigation Unit

| Sr. No. | Source | Crop | Total water applied No. of rotations or days | No. of hours per day | Area irrigated | Total production Ton & Rupees) |
|---|---|---|---|---|---|---|
| 1. | Lift Irrigation scheme | | | | | |
| 2. | Drip Irrigation unit | | | | | |

XIV. Water use efficiency in both, Lift Irrigation Scheme and Drip Irrigation Unit

| Sr. No. | Source | Increased area under irrigation (ha) | Present production (Rs.) | Past production (Rs.) | Addi-production (Rs.) |
|---|---|---|---|---|---|
| 1. | Lift Irrigation Scheme | | | | |
| 2. | Drip Irrigation Unit | | | | |

(App. I : Contd....)

What is discharge rate of water per hour ?

1. For Lift Irrigation Scheme .....
2. For Drip Irrigation Unit .....

XV. Management opinion about Lift Irrigation Scheme and Drip Irrigation Unit

1. What is seasonal availability of irrigation water ?
   e.g. is adequate water,
   is available for all seasons
2. What is method of deliverying water ?

   Contineous flow, rotation, demand, etc. Is it suitable ? If not, why ?
3. Are water users active in the proper utilization of water ?

   Yes/No

   If no, Describe reason
4. What is method of water charges collection and response of beneficiaries towards water charges payment i.e. mode of payment
5. What are the factors responsible for efficient use of irrigation water ?
6. Are there any restrictions by Government on cropping pattern to be irrigated under Lift Irrigation Scheme? Describe its effect on Scheme
7. By application of drip irrigation system is there any increase in irrigated area ? (at what quantity it is increased), If the answer is 'Yes'
8. What is the additional cost of drip irrigation method ? Which new material has been used ?
9. Whether total production and yield has been increased or not ?
10. Whether there is any reduction in hours of irrigation water application or number of rotations of water ?
11. What are the other beneficial effects received from drip irrigation system ?

(App. I : Contd....)

B. FOR FARMER

I. General information of the family

(a) Head of the family

1. Name
2. Age
3. Village
4. Tahsil
5. District
6. Education
7. Main occupation
8. Subsidiary occupation
9. No. of years of application of drip irrigation set
10. Which drip irrigation system is available for sugarcane ? Whether drip method or biwall system ?

II. Family size and its composition

| Sr. No. | Name of the family member | Relation with head | Age | Education | Occupation |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |

III. Information about land holding

| Type | Survey No. | Area (ha) | Area under cultivation | | Fallow land | Land Revenue | Value of land |
|---|---|---|---|---|---|---|---|
| | | | Dry (ha) | Irr. (ha) | (ha) | (Rs) | (Rs) |
| Owned land | | | | | | | |

IV. Information about farm assets

(a) Farm buildings

| Sr. No. | Type | Type of construction | Year of construction | Cost of construction (Rs) | Present rate (Rs) | Remaining life (Yrs) | Cost of repairing (Rs) |
|---|---|---|---|---|---|---|---|
| 1. | Residential house | | | | | | |
| 2. | Farm house | | | | | | |
| 3. | Byre | | | | | | |
| 4. | Store | | | | | | |
| 5. | Other | | | | | | |

(b) Wells

| Sr. No. | Type of construction | Year of construction | Cost of construction (Rs.) | Present value (Rs.) | Remaining life (Yrs) | Cost of repairing (Rs) |
|---|---|---|---|---|---|---|
| | | | | | | |

(c) Farm implements and machinery

| Sr. No. | Type and Number | Year of purchase | Value (Rs.) | Present value (Rs.) | Remaining life (Yrs) | Cost of repairing (Rs.) |
|---|---|---|---|---|---|---|
| 1. | Iron plough | | | | | |
| 2. | Wooden plough | | | | | |
| 3. | Seed drill | | | | | |
| 4. | Harrow | | | | | |
| 5. | Hoe | | | | | |
| 6. | Bullock-cart | | | | | |
| 7. | Duster | | | | | |
| 8. | Sprayer | | | | | |
| Machinery | | | | | | |
| 1. | Oil engine | | | | | |
| 2. | Elec. motor | | | | | |
| 3. | Tractors | | | | | |
| 4. | Others | | | | | |
| Tools | | | | | | |
| 1. | Pickaxe | | | | | |
| 2. | Spade | | | | | |
| 3. | Sickles | | | | | |
| 4. | Weeding hooks | | | | | |

(d) Livestock

| Sr. No. | Type Owned/Purchased | | Number | Year of purchase | Price of purchase (Rs) | Present value (Rs) | Age (Yrs) | Remaining life (Yrs) |
|---|---|---|---|---|---|---|---|---|
| 1. | Breeding bulls | - Owned | | | | | | |
| | | - Purchased | | | | | | |
| 2. | Draft animals | | | | | | | |
| | (a) Bullock | - Owned | | | | | | |
| | | - Purchased | | | | | | |
| 3. | Milch animals | | | | | | | |
| | (a) Cows | - Owned | | | | | | |
| | | - Purchased | | | | | | |
| | (b) Buffaloes | - Owned | | | | | | |
| | | - Purchased | | | | | | |
| 4. | Calves | | | | | | | |
| | (a) Cow calves | - Owned | | | | | | |
| | | - Purchased | | | | | | |
| | (b) Buffalo calves | - Owned | | | | | | |
| | | - Purchased | | | | | | |
| 5. | Goat | | | | | | | |
| 6. | Poultry birds | | | | | | | |

V. Capital requirement for drip irrigation set

| Total investment for drip irrigation set | Owned capital | Loan | | | | | Subsidy percentage |
|---|---|---|---|---|---|---|---|
| | | Source | Amount (Rs.) | Rate of interest (Rs.) | Repayment period (Yrs) | Percentage (Rs.) | (Rs.) |
| | | | | | | | |

(App. I : Contd....)

VI. Detail information about farmers irrigated land

| Sr. No. | Source of irrigation | Seasonal irrigated area (ha) | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Crop | Area (ha) | Crop | Area (ha) | Crop | Area (ha) | Crop | Area (ha) | (ha) |
| 1. | Before drip irrigation | | | | | | | | | |
| 2. | After drip irrigation | | | | | | | | | |

VII. Cropping pattern of farmer before drip irrigation and after drip irrigation

| Sr. No. | Crop | Variety | Kharif | | Rabi | | Summer | | Perennial | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Area (ha) | Production (q) | Area (ha) | Production (q) | Area (ha) | Production (q) | Area (ha) | Production (q) |
| 1. | Before drip irrigation | | | | | | | | | |
| | (a) Irrigated | | | | | | | | | |
| | (b) Dry | | | | | | | | | |
| 2. | After drip irrigation | | | | | | | | | |
| | (a) Irrigated | | | | | | | | | |
| | (b) Dry | | | | | | | | | |

VIII. Resource use and production cost structure of crops

| Sr. No. | Crop | Whether mixed or sole | Irri./ Unirri. | Var. | Area | Preparatory tillage | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Family labours (days) | | | Hired labours (days) | | | Tractor power (hrs) |
| | | | | | | Men | Women | Bullock pair | Men | Women | Bullock pair | Machinery (days) |
| A. Before drip irrigation | | | | | | | | | | | | |
| 1. | | | | | | | | | | | | |
| 2. | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | |
| B. After drip irrigation | | | | | | | | | | | | |
| 1. | | | | | | | | | | | | |
| 2. | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | |

(App. I : Contd....)

IX. Transport and application of manure

| Quantity of manure (tons) | | Total value of manure (Rs.) | Labour requirement (days) | | | | | | Tractor power (hr) Machinery charges (Rs.) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Family labour | | | Hired labour | | | |
| Farm produced | Purchased | | Men | Women | Bullock pair | Men | Women | Bullock pair | |
| A. | | | | | | | | | |
| B. | | | | | | | | | |

X. Sowing/planting/transplanting

| Quantity of seeds | | Total value of seeds (Rs.) | Labour requirement (days) | | | | | | Spacing |
|---|---|---|---|---|---|---|---|---|---|
| | | | Family labour | | | Hired labour | | | |
| Farm produced | Purchased | | Men | Women | Bullock pair | Men | Women | Bullock pair | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| A. | | | | | | | | | |
| B. | | | | | | | | | |

| Tractor power(hr) Machinery charges | Interculturing/weedingearthing-up | | | | | | Tractor power (hr) machinery charges |
|---|---|---|---|---|---|---|---|
| | Family labour | | | Hired labour | | | |
| | Men | Women | Bullock pair | Men | Women | Bullock pair | |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| A. | | | | | | | |
| B. | | | | | | | |

(App. I : Contd.....)

XI. Fertilizer use

| | Quantity of fertilizer (kg) | N (kg) | $P_2O_5$ (kg) | $K_2O$ (kg) | Total value (Rs.) | Labour requirement (days) | | | | | | Tractor power (hr) Machinery charges (Rs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Family labour | | | Hired labour | | | |
| | | | | | | Men | Women | Bullock pair | Men | Women | Bullock pair | |
| A. | | | | | | | | | | | | |
| B. | | | | | | | | | | | | |

XII. Irrigation

| Labour requirement (days) | | | | Sources and expenditure on irrigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Family labour | | Hired labour | | Charges of canal water | Oil engine expenditure | Elec. meter expenditure | Canal water expenditure | Lift irrigation Sch. expenditure | Expenditure on drip irrigation | Expenditure on hiring from others |
| Men | Women | Men | Women | (Rs.) | (Rs.) | (Rs.) | (Rs.) | (Rs.) | (Rs.) | (Rs.) |
| A. | | | | | | | | | | |
| B. | | | | | | | | | | |

XIII. Plant protection

| Quantity of | | | Total value | Labour requirement (days) | | | | Hiring charges of sprayers & dusters (Rs.) |
|---|---|---|---|---|---|---|---|---|
| | | | | Family labour | | Hired labour | | |
| Insecticide (kg) | Pesticide (kg) | Fungicide (kg) | (Rs.) | Men | Women | Men | Women | |
| A. | | | | | | | | |
| B. | | | | | | | | |

(App. I : Contd.....)

XIV. Harvesting and threshing

| | Labour requirement (days) | | | | | | Tractor powr | Thresher power | Total machinery charges | Cost of gunny bags |
|---|---|---|---|---|---|---|---|---|---|---|
| | Family labour | | | Hired labour | | | | | | |
| | Men | Women | Bullock pair | Men | Women | Bullock pair | (hr) | (hr) | (Rs.) | (Rs.) |
| A. | | | | | | | | | | |
| B. | | | | | | | | | | |

XV. Output

| | Main crop (Qty.) | | Value of output | | Mixed crop (Qty.) | | Value of output | Average wage rate (Rs.) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Main product | Byproducts | Main prod. | By product | Main product | Byproducts | | Men | Women | Bullock pair |
| | (q) | (q) | (Rs) | (Rs) | (q) | (q) | (Rs.) | | | |
| A. | | | | | | | | | | |
| B. | | | | | | | | | | |

XVI. Irrigation use and irrigation costs

| Crops | Before drip irrigation | | | | | After drip irrigation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of rotations or days of irrigation | No. of hours of water applied per day | Area irrigated | Total production | Water charges per hour | No. of rotations or days of irrigation | No. of hours of water applied per day | Area irrigated | Total production | Water charges per hour |
| | | | (ha) | (q) | (Rs.) | | | (ha) | (q) | (Rs.) |
| 1. | | | | | | | | | | |
| 2. | | | | | | | | | | |
| 3. | | | | | | | | | | |
| 4. | | | | | | | | | | |
| 5. | | | | | | | | | | |

(App. I : Contd...)

(App. I : Contd...)

XVII. Farm employment

| Item | Labour (days) | | |
|---|---|---|---|
| | Men | Women | Bullock pair |
| 1. Labour for livestock (Feeding, cleaning, collection of waste material, cleaning of byre, taking care of young ones) | | | |
| 2. Labour for poultry (Feeding, cleaning) | | | |
| 3. Labour for repairing of bunds, cleaning of bunds, etc.) | | | |
| 4. Labour for repairing of wells | | | |
| 5. Labour for repairing of house, etc. | | | |

What is discharge of water per hour ?

1. Before drip irrigation .....
2. After drip irrigation .....

Other information :

1. Whether it is necessary to change the quantity of water which is given through drip irrigation method according to soil pH, type of soil ?
2. What is your experience about drip irrigation method to crops ---
   (a) Saving of water .....
   (b) Labour charges .....
   (c) Application of FYM ...
   (d) Necessity of plant protection ....
   (e) Effect of interculturing .....
   (f) Total production of crop and quality ....
   (g) Drip irrigation is useful to which crops other than present crop .....

(App. I : Contd....)

3. Experience in utilization of drip irrigation set --
   (a) Operating knowledge .....
   (b) Full information about set ....
   (c) Facilities available for repair of nozzles, drippers.....
   (d) Availability of spare parts, chemicals, etc.

4. What are the possible losses of laterals, other parts through rats, children ?

5. Do you know the technique of application of urea through water ? Whether you can apply it ?

6. If urea is applied through irrigation, what happened to pipes, whether they are choked-up ?

7. Availability of loan
   (a) What amount of loan is required per hectare ? What is the percentage of subsidy on it ?
   (b) Distribution of loan ..... Proper/Improper
   (c) Distribution of subsidy ... Sufficient/ Insufficient

8. Is there any change in number of hours of application of water through drip method ?

9. Whether it is possible to use salty water through drip irrigation ? Can you use it ?

10. Do you clean the nozzles, valves regularly ?

    Yes/No

    If no, Why ?
    (a) Cleaning is difficult
    (b) Non-availability of material
    (c) Not necessary to clean it
    (d) Absence of knowledge about cleaning it

11. Which company gives the best drip irrigation set with respect to price, life period, etc. ?

12. As drip irrigation is useful for sugarcane, fruit crops, how many farmers (in percentage) have adopted it ? Reasons for not application ?

13. Other suggestions of farmers, if any.

## Appendix-II

### Evaluation and Allocation of costs

A. Evaluation of costs

1. Crops : Both main and by-products evaluated at prices prevailing in the village at the time of harvesting.

2. Human labour : Hired labour evaluated at the actual amount paid both in cash and kind, the latter at harvest price. In case of family labour, the valuation was done at the wage rates prevailing in the village for hired labour.

3. Bullock labour : The hired bullock labour evaluated according to actual amount paid in cash and kind. Owned bullock labour on the basis of cost of maintenance.

4. Depreciation : A straight line method was adopted for depreciation charges. The depreciation was charged according to the expected life of the assets. The value of major repairs during the year was capitalized and depreciation charged on the total amount.

5. Rent on land : The rent on land was evaluated in terms of 1/6th value of gross produce of the crop.

6. Interest on working capital : This was charged at the prevailing bank rate of interest on crop loans, i.e. for the half period crop life @ 13 per cent.

7. Interest on fixed capital : This was charged on the agricultural capital assets excluding value of land @ 10 per cent.

(App. II : Contd.....)

B. Allocation of costs over crops

1. Depreciation : Depreciation on farm buildings in proportion of the value of output of a crop was allocated. Depreciation on bullock drawn implements was allocated according to number of pair-days of bullock labour used for a crop, while criterion of human labour input was used for allocating depreciation on other implements. In case of farm machineries, the depreciation was allocated according to their use for different crops.

2. Land tax : Proportional to the area under crop to total cropped area was allocated.

3. Interest on fixed capital : Allocated in proportion of the depreciation charged for individual crops.

Concepts of cost

The costs of inputs used in production of crops are arrived at according to 3 cost concepts i.e. Cost-A, Cost-B and Cost-C. These three costs include items as follows :

Cost-A : This covers

1. Value of hired human labour
2. Value of hired bullock labour
3. Value of owned bullock labour
4. Value of seed (farm produced and purchased)
5. Value of manures (farm produced and purchased) and fertilizers
6. Value of insecticides and pesticides.
7. Expenditure on irrigation
8. Land tax and other taxes
9. Depreciation
10. Miscellaneous expenses
11. Interest on working capital.

Cost-B : Cost-A + Rental value of owned land + interest on owned fixed capital (excluding land)

Cost-C : Cost-B + imputed value of family labour.

Per hectare labour and machinery power requirements of different crops

| Productivity Group | Crops | | | | | |
|---|---|---|---|---|---|---|
| | Kharif jowar | Soybean | Groundnut | Wheat | Gram | Grapes |
| | | | BEFORE DRIP IRRIGATION | | | |
| Low | | | | | | |
| a) Men labour (days) | 29.64 | 26.89 | 44.44 | 39.59 | 32.15 | 556.25 |
| b) Women labour (days) | 43.57 | 20.16 | 50.00 | 6.95 | 42.72 | 268.75 |
| c) B. labour (pair days) | 2.50 | 4.83 | 8.33 | 4.34 | 3.91 | - |
| d) Machinery (hours) | 12.14 | 0.71 | 11.11 | 12.60 | 11.93 | 15.62 |
| Medium | | | | | | |
| a) Men labour (days) | 49.37 | 32.20 | 27.50 | 44.71 | 24.44 | - |
| b) Women labour (days) | 47.50 | 33.46 | 32.50 | 31.25 | 22.88 | - |
| c) B. labour (pair days) | 7.81 | 2.30 | 5.00 | 2.71 | 1.33 | - |
| d) Machinery (hours) | 6.25 | 11.92 | 10.00 | 9.71 | 9.11 | - |
| High | | | | | | |
| a) Men labour (days) | 26.47 | 23.40 | - | 32.84 | 15.00 | 515.55 |
| b) Women labour (days) | 57.27 | 32.20 | - | 62.06 | 56.92 | 347.22 |
| c) B. labour (pair days) | 3.18 | 3.20 | - | 1.55 | 4.61 | 7.77 |
| d) Machinery (hours) | 15.45 | 15.60 | - | 12.93 | 12.30 | 30.55 |
| Overall | | | | | | |
| a) Men labour (days) | 31.56 | 28.82 | 35.52 | 39.57 | 25.03 | 534.70 |
| b) Women labour (days) | 47.44 | 29.27 | 40.78 | 47.27 | 33.87 | 310.29 |
| c) B. labour (pair days) | 3.16 | 3.78 | 6.57 | 2.81 | 2.57 | 4.11 |
| d) Machinery (hours) | 12.44 | 9.51 | 10.52 | 6.40 | 6.53 | 23.52 |



Contd.....

Contd...

| Productivity Group | Crops | | | | | | |
|---|---|---|---|---|---|---|---|
| | Kharif jowar | Soybean | Rabi jowar | Wheat | Gram | Grapes | Sugarcane (Surface method) |
| | | | AFTER DRIP IRRIGATION | | | | |
| Low | | | | | | | |
| a) Men labour (days) | 39.28 | 26.50 | 75.00 | 41.71 | 68.75 | - | 119.67 |
| b) Women labour (days) | 58.92 | 31.00 | 95.00 | 50.00 | - | - | 109.83 |
| c) B. labour (pair days) | 4.46 | 8.37 | 9.50 | 2.50 | 2.50 | - | 5.06 |
| d) Machinery (hours) | 14.64 | 10.50 | 15.00 | 12.50 | 10.93 | - | 16.23 |
| Medium | | | | | | | |
| a) Men labour (days) | 18.25 | 39.16 | 45.00 | 54.16 | 17.50 | - | 110.40 |
| b) Women labour (days) | 45.00 | 53.33 | 100.00 | 52.50 | 50.00 | - | 110.93 |
| c) B. labour (pair days) | 5.75 | 6.66 | 7.50 | 0.83 | 2.50 | - | 4.53 |
| d) Machinery (hours) | 10.50 | 18.33 | 11.25 | 11.66 | 7.50 | - | 12.31 |
| High | | | | | | | |
| a) Men labour (days) | 27.91 | 22.14 | 34.37 | 49.16 | 102.50 | 510.00 | 125.54 |
| b) Women labour (days) | 25.00 | 41.07 | 25.00 | 59.16 | 25.00 | 217.50 | 114.21 |
| c) B. labour (pair days) | 2.50 | 2.14 | 5.00 | 0.83 | 3.75 | 5.00 | 5.73 |
| d) Machinery (hours) | 10.83 | 15.35 | 12.50 | 13.33 | 10.00 | 19.06 | 17.95 |
| Overall | | | | | | | |
| a) Men labour (days) | 30.00 | 26.87 | 47.18 | 49.45 | 56.42 | 510.00 | 117.76 |
| b) Women labour (days) | 48.33 | 38.00 | 61.25 | 55.15 | 28.97 | 217.50 | 111.97 |
| c) B. labour (pair days) | 3.66 | 3.18 | 6.75 | 3.28 | 2.85 | 5.00 | 5.62 |
| d) Machinery (hours) | 12.50 | 13.37 | 12.81 | 13.43 | 10.35 | 19.06 | 15.20 |

Per hectare seeds, manures, fertilizers, plant protection measures for sample farm

| Productivity Group | Crops | | | | | | |
|---|---|---|---|---|---|---|---|
| | Kharif jowar | Soybean | Groundnut | Wheat | Gram | Grapes | Sugarcane (Surface method) |
| | BEFORE DRIP IRRIGATION | | | | | | |
| Low | | | | | | | |
| a) Seeds (kg) | 7.50 | 71.42 | 55.55 | 41.30 | 59.09 | 4375.00* | - |
| b) Manures (C/L) | 19.28 | 16.38 | 27.77 | 18.26 | 17.72 | 75.00 | - |
| c) Fertilizers (kg) | | | | | | | |
| N | 27.05 | 66.09 | - | 56.84 | 21.18 | 217.50 | - |
| $P_2O_5$ | 13.39 | 7.35 | - | 15.10 | - | 605.00 | - |
| $K_2O$ | 7.67 | 3.15 | - | 1.63 | - | 322.50 | - |
| d) Plant protection chemicals (kg/ml) | - | - | - | - | - | - | - |
| Medium | | | | | | | |
| a) Seeds (kg) | 11.25 | 67.94 | 62.50 | 57.14 | 70.00 | - | - |
| b) Manures (C/L) | 30.00 | 23.71 | 25.00 | 19.42 | 10.22 | - | - |
| c) Fertilizers (kg) | | | | | | | |
| N | 64.50 | 29.65 | - | 97.25 | 21.02 | - | - |
| $P_2O_5$ | 16.25 | 40.38 | - | 10.71 | 27.33 | - | - |
| $K_2O$ | 16.25 | 15.38 | - | 10.71 | 20.00 | - | - |
| d) Plant protection chemicals (kg/ml) | - | 30.00 kg | - | - | 2.66 kg | - | - |

Contd.....

Contd....

| Productivity Group | Crops | | | | | | |
|---|---|---|---|---|---|---|---|
| | Kharif jowar | Soybean | Rabi jowar | Wheat | Gram | Grapes | Sugarcane (Surface method) |
| | AFTER DRIP IRRIGATION | | | | | | |
| Low | | | | | | | |
| a) Seeds (kg) | 8.21 | 70.75 | 26.67 | 43.12 | 56.25 | - | 25217.39 |
| b) Manures (C/L) | 22.50 | 18.50 | 33.60 | 18.12 | 17.50 | - | 32.60 |
| c) Fertilizers (kg) | | | | | | | |
| N | 22.60 | 20.07 | 116.50 | 99.34 | - | - | 759.79 |
| $P_2O_5$ | 31.42 | 30.75 | - | 4.68 | - | - | 416.95 |
| $K_2O$ | 20.00 | 3.75 | - | 4.68 | - | - | 406.95 |
| d) Plant protection chemicals (kg/ml) | - | - | - | - | - | - | - |
| Medium | | | | | | | |
| a) Seeds (kg) | 9.50 | 62.50 | 30.00 | 50.00 | 62.50 | - | 24250.00 |
| b) Manures (C/L) | 20.00 | 25.00 | 25.00 | 25.00 | 25.00 | - | 30.93 |
| c) Fertilizers (kg) | | | | | | | |
| N | 12.50 | 28.16 | 84.50 | 116.50 | - | - | 400.84 |
| $P_2O_5$ | 32.50 | 22.50 | 67.50 | - | - | - | 200.12 |
| $K_2O$ | 32.50 | - | - | - | - | - | 276.00 |
| d) Plant protection chemicals (kg/ml) | - | - | - | - | - | - | - |

Contd...

Contd....

| Productivity Group | Crops | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Kharif jowar | Soybean | Groundnut | Wheat | Gram | Grape | Rabi jowar | Sugarcane (Surface method) |
| | | | | BEFORE DRIP IRRIGATION | | | | |
| High | | | | | | | | |
| a) Seeds (kg) | 8.18 | 75.00 | - | 45.51 | 46.15 | 8333.33* | - | - |
| b) Manures (C/L) | 28.18 | 24.40 | - | 22.41 | 3.84 | 94.44 | - | - |
| c) Fertilizers (kg) | | | | | | | | |
| N | 17.40 | 47.22 | - | 49.65 | 8.07 | 260.00 | - | - |
| $P_2O_5$ | 17.72 | 37.60 | - | 12.24 | 20.76 | 446.11 | - | - |
| $K_2O$ | 17.72 | 5.20 | - | 12.24 | - | 272.22 | - | - |
| d) Plant protection chemicals (kg/ml) | - | - | - | - | - | 5.55 lit ( 222.22 kg) | | |
| Overall | | | | | | | | |
| a) Seeds (kg) | 8.02 | 70.89 | 59.21 | 47.45 | 63.12 | 1641.79* | - | - |
| b) Manures (C/L) | 22.55 | 21.92 | 26.31 | 19.72 | 9.87 | 21.64 | - | - |
| c) Fertilizers (kg) | | | | | | | | |
| N | 28.06 | 44.53 | - | 67.80 | 17.96 | 60.89 | - | - |
| $P_2O_5$ | 14.76 | 30.63 | - | 12.95 | 15.37 | 132.16 | - | - |
| $K_2O$ | 11.04 | 9.16 | - | 7.31 | 11.25 | 75.07 | - | - |
| d) Plant protection chemicals (kg/ml) | - | 0.68 kg | - | - | 1.50 kg | 2.94 Lit. 117.64 | | |

* Cuttings

Contd....

| Productivity Group | Crops | | | | | | |
|---|---|---|---|---|---|---|---|
| | Kharif jowar | Soybean | Rabi jowar | Wheat | Gram | Grapes | Sugarcane (Surface method) |
| | AFTER DRIP IRRIGATION | | | | | | |
| High | | | | | | | |
| a) Seeds (kg) | 8.33 | 69.64 | 10.00 | 54.16 | 75.00 | 4750.00* | 25774.84 |
| b) Manures (C/L) | 25.00 | 14.28 | 25.00 | 25.00 | 25.00 | 83.75 | 35.49 |
| c) Fertilizers (kg) | | | | | | | |
| N | 8.33 | 48.28 | 38.50 | 17.00 | - | 221.88 | 441.46 |
| $P_2O_5$ | 21.66 | 38.57 | 9.37 | 13.95 | - | 600.00 | 235.14 |
| $K_2O$ | 21.66 | - | 9.37 | 13.95 | - | 328.13 | 339.50 |
| d) Plant protection chemicals (kg/ml) | - | - | - | - | - | - | - |
| Overall | | | | | | | |
| a) Seeds (kg) | 8.66 | 69.12 | 19.17 | 51.25 | 64.28 | 4750.00* | 25013.47 |
| b) Manures (C/L) | 22.16 | 18.00 | 27.15 | 23.12 | 22.85 | 83.75 | 32.99 |
| c) Fertilizers (kg) | | | | | | | |
| N | 16.38 | 31.16 | 69.50 | 109.17 | - | 221.88 | 483.15 |
| $P_2O_5$ | 29.83 | 32.25 | 21.56 | 7.57 | - | 600.00 | 253.85 |
| $K_2O$ | 24.50 | 1.87 | 4.68 | 7.57 | - | 328.13 | 324.69 |
| d) Plant protection chemicals (kg/ml) | - | - | - | - | - | - | - |

* Cuttings



(App. IV : Contd...)

Per hectare production costs of different crops on sample farms

(Rupees)

| Crop | Sugarcane productivity group | | | | | |
|---|---|---|---|---|---|---|
| | Low | | | Medium | | |
| | Cost-A | Cost-B | Cost-C | Cost-A | Cost-B | Cost-C |
| | BEFORE DRIP IRRIGATION | | | | | |
| Kharif jowar | 2712.98 (68.84) | 3512.58 (89.13) | 3941.08 (100.00) | 4083.24 (75.65) | 4782.68 (88.61) | 5397.68 (100.00) |
| Soybean | 3437.00 (64.40) | 5031.79 (94.28) | 5336.89 (100.00) | 3622.85 (56.04) | 6014.57 (93.03) | 6465.27 (100.00) |
| Groundnut | 4179.72 (62.26) | 6146.60 (91.55) | 6713.60 (100.00) | 3428.90 (35.13) | 9346.77 (95.75) | 9761.77 (100.00) |
| Wheat | 2485.10 (67.20) | 3631.83 (98.22) | 3697.83 (100.00) | 3391.93 (64.67) | 4877.77 (93.00) | 5244.97 (100.00) |
| Gram | 5250.83 (62.88) | 6345.41 (75.98) | 8350.91 (100.00) | 2846.35 (58.76) | 4528.86 (93.49) | 4844.26 (100.00) |
| Grapes | 42309.90 (62.64) | 63441.33 (93.92) | 67546.53 (100.00) | - | - | - |
| | High | | | Overall | | |
| | Cost-A | Cost-B | Cost-C | Cost-A | Cost-B | Cost-C |
| Kharif jowar | 3314.27 (74.10) | 4053.65 (90.63) | 4472.83 (100.00) | 2996.12 (72.74) | 3723.37 (90.40) | 4118.96 (100.00) |
| Soybean | 3445.39 (53.85) | 5988.24 (93.59) | 6398.35 (100.00) | 3461.14 (56.62) | 5690.56 (93.10) | 6112.39 (100.00) |
| Groundnut | - | - | - | 3807.30 (45.88) | 7820.45 (94.24) | 8298.43 (100.00) |
| Wheat | 3014.57 (57.34) | 4818.97 (91.66) | 5257.37 (100.00) | 2755.45 (53.94) | 4343.82 (85.04) | 5107.98 (100.00) |
| Gram | 2509.45 (54.48) | 4290.03 (93.14) | 4605.88 (100.00) | 2806.91 (61.15) | 4352.75 (94.83) | 4589.92 (100.00) |
| Grapes | 42032.32 (67.34) | 58840.31 (94.27) | 62418.75 (100.00) | 42959.00 (65.76) | 61483.35 (94.12) | 65324.30 (100.00) |





Contd.....

Contd.....

(Rupees)

| Crop | Sugarcane productivity group | | | | | |
|---|---|---|---|---|---|---|
| | Low | | | Medium | | |
| | Cost-A | Cost-B | Cost-C | Cost-A | Cost-B | Cost-C |
| | AFTER DRIP IRRIGATION | | | | | |
| Kharif jowar | 4947.06 (73.93) | 6039.37 (90.25) | 6691.57 (100.00) | 3847.70 (75.00) | 4582.52 (89.33) | 5129.80 (100.00) |
| Soybean | 4835.14 (66.80) | 6727.35 (92.94) | 7238.47 (100.00) | 5656.75 (61.13) | 8635.01 (93.32) | 9253.21 (100.00) |
| Rabi jowar | 6054.20 (66.15) | 7847.47 (85.74) | 9152.77 (100.00) | 6156.46 (72.22) | 7324.33 (85.92) | 8524.43 (100.00) |
| Wheat | 4142.47 (63.61) | 5806.53 (89.17) | 6512.08 (100.00) | 7344.59 (67.30) | 9261.86 (84.87) | 10912.56 (100.00) |
| Gram | 3883.02 (76.21) | 4662.83 (91.51) | 5095.23 (100.00) | 4544.75 (64.59) | 6586.41 (93.61) | 7036.01 (100.00) |
| Grapes | - | - | - | - | - | - |
| Sugarcane (Surface method) | 24787.07 (72.30) | 32969.99 (96.17) | 34281.29 (100.00) | 18425.48 (69.43) | 25579.92 (96.39) | 26538.62 (100.00) |
| | High | | | Overall | | |
| | Cost-A | Cost-B | Cost-C | Cost-A | Cost-B | Cost-C |
| Kharif jowar | 4142.99 (77.22) | 4962.68 (92.49) | 5365.38 (100.00) | 4214.21 (73.09) | 5113.14 (88.69) | 5765.46 (100.00) |
| Soybean | 4358.71 (59.16) | 6904.58 (93.72) | 7367.22 (100.00) | 4562.13 (62.74) | 6858.18 (94.31) | 7271.94 (100.00) |
| Rabi jowar | 3923.46 (67.42) | 5251.84 (90.25) | 5819.01 (100.00) | 5107.44 (68.80) | 6513.19 (87.74) | 7423.12 (100.00) |
| Wheat | 5179.14 (64.89) | 7224.58 (90.52) | 7981.02 (100.00) | 4581.97 (63.40) | 6700.73 (92.72) | 7226.73 (100.00) |
| Gram | 6938.75 (76.70) | 8341.76 (92.20) | 9047.10 (100.00) | 5023.17 (71.44) | 6610.89 (94.02) | 7031.37 (100.00) |
| Grapes | 34972.80 (61.57) | 52696.97 (92.77) | 56802.17 (100.00) | 34972.80 (61.57) | 52696.97 (92.77) | 56802.17 (100.00) |
| Sugarcane (Surface method) | 19223.53 (67.19) | 27717.65 (96.88) | 28609.99 (100.00) | 22591.28 (71.48) | 30560.13 (96.70) | 31602.67 (100.00) |

(Figures in parentheses are percentages to Cost-C).

(App. V : Contd.....)

Per hectare total output and returns of crops on sample farm

| Crop | Low sugarcane productivity group | | Medium sugarcane productivity group | | High sugarcane productivity group | | Overall sugarcane productivity group | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (q) | Value (Rs.) | Quantity (q) | Value (Rs.) | Quantity (q) | Value (Rs.) | Quantity (q) | Value (Rs.) |
| | | | | BEFORE DRIP IRRIGATION | | | | |
| Kharif jowar | 14.82 | 2742.00 | 12.50 | 3000.00 | 18.18 | 3017.00 | 15.46 | 2836.00 |
| Soybean | 13.86 | 7623.00 | 16.15 | 13129.00 | 22.80 | 13816.00 | 17.53 | 11843.00 |
| Groundnut | 5.55 | 6660.00 | 25.00 | 32500.00 | - | - | 15.78 | 20245.00 |
| Wheat | 14.78 | 6873.00 | 16.28 | 7407.00 | 19.31 | 9037.00 | 16.45 | 7616.00 |
| Gram | 7.27 | 4507.00 | 7.11 | 8887.00 | 15.38 | 9262.00 | 8.50 | 7743.00 |
| Grapes | 212.50 | 106250.00 | - | - | 200.00 | 866666.00 | 205.80 | 958440.00 |
| | | | | AFTER DRIP IRRIGATION | | | | |
| Kharif jowar | 22.50 | 4500.00 | 16.00 | 3200.00 | 17.50 | 3500.00 | 19.33 | 3866.00 |
| Soybean | 14.50 | 9295.00 | 25.00 | 16650.00 | 22.85 | 13852.00 | 19.00 | 12000.00 |
| Rabi jowar | 15.00 | 5625.00 | 10.00 | 4000.00 | 12.50 | 4425.00 | 12.50 | 4618.00 |
| Wheat | 14.37 | 9987.00 | 20.00 | 10000.00 | 21.66 | 10496.00 | 19.00 | 10769.00 |
| Gram | 3.75 | 2625.00 | 17.50 | 12250.00 | 10.00 | 7000.00 | 11.42 | 7994.00 |
| Grapes | - | - | - | - | 237.50 | 1187500.00 | 237.50 | 1187500.00 |
| Sugarcane (Surface method) | 99.85* | 35050.90 | 95.00 | 34881.20 | 101.12 | 41617.00 | 98.27* | 37600.60 |

*(In tonnes)

# Vita

# 9. VITA

Prashant Prabhakar Inamdar
A candidate for the degree
of
MASTER OF SCIENCE (AGRICULTURE)
in
AGRICULTURAL ECONOMICS
1994

| | |
|---|---|
| Title of Thesis | Economic Efficiency of Drip Irrigation in Sugarcane Production in the Command of Cooperative Lift Irrigation Project in Sangli District |
| Major Field | Agricultural Economics |
| Biographical Information | |
| o Personal bio-data | Born at Tasgaon, Tal. Tasgaon, Dist. Sangli on 22nd July, 1969. Son of Shri Prabhakar V. Inamdar having two brothers. |
| o Education | Attended primary school at Tasgaon, secondary school and junior college at Vidyaneeketan Krishi Madhyamik Vidyalaya, and Junior college, Tasgaon.<br><br>Received the Bachelor of Science (Agriculture) degree in First Class from the College of Agriculture, Kolhapur in 1991 and completed the requirements of the Master of Science (Agriculture) degree in Agricultural Economics at Mahatma Phule Agriculture University, Rahuri, Dist. Ahmednagar in 1994.<br><br>Recipient of I.C.A.R. Merit Scholarship during graduation period from 1987-88 to 1990-91. |