SOCIAL IMPACT OF TECHNICAL INNOVATIONS

Study of Organic Cotton and Low Cost Drip Irrigation in the Agrarian Economy of West Nimar Region

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Executive Summary

The socio-economic photo offers insights into the decision making processes behind and the impact of the adoption of two innovations in the Maikaal region: organic farming of cotton and micro irrigation. This report presents a synthesis of several studies carried out by IWMI under the SDC supported Maikaal Research Project. The report also draws upon related IWMI research on the theme of Mass Promotion of Micro-Irrigation Technologies in India.

Analysis of the data collected over the past 18 months suggests that while on the one hand, adoption of organic farming leads to more than 50% increase in the (average) net profit per acre of farmers; adoption of micro irrigation leads to more than 20% increase in per acre (average) returns and (on an average) brings an additional 2.2 acres of land under irrigation. These are significant benefits accruing to farmers adopting these technologies. One significant finding of the study is that when used in conjunction, the innovations would lead to maximum returns for the farmers. This is indicated in the table below:

	Average Price/Quintal	Average Yield/Acre	Average Costs/Acre	Average Profit/Acre	**Incremental Gain**
Chemical Farmers without Drip Adoption	2569.51	4.27	4152.08	6331.52	
Chemical Farmers with Drip Adoption	2764.55	3.82	3893.69	7385.67	**16.65**
Organic Farmers without Drip Adoption	3083.41	4.35	3600.74	9257.09	**29.56**
Organic Farmers with Drip Adoption	3317.46	3.94	3600.74	10233.07	**15.41**

Our studies also suggest that, both the innovations are still seen by the farmers as short-run coping strategies to situations of water scarcity (in the case of micro-irrigation) and working capital shortages (in the case of organic farming), but it won't be long before these innovations will be adopted by the farmers as enduring shifts in farming approaches.

The organic movement in the Maikaal region has now become much larger than bioRe itself and seems to have emerged as a sound business proposition in the region, if the rise of two private organic projects in the region is any guide. At the same time, there are also indications that many farmers' adoption of organic farming is driven by opportunism rather than intrinsic faith in its virtuosity. Equally, the adoption of micro-tubes and Pepsee systems too is largely motivated by the desire to increase the area under irrigation—by 2-3 acres per farmer on average-- rather than the desire to adopt environmentally sustainable agriculture. These findings are not surprising considering that farmers consider their main challenge to be one of stabilizing their livelihood systems based on risk-prone, low-yielding, small-scale farming systems.

The veracity of our conclusions is weakened somewhat by the limitations of our data sets and certain flaws in the research method adopted. owever, we believe it extremely unlikely that better studies using superior methodologies and data sets will come to opposite conclusions than ours. In sum, we believe that net, real, farm-holding wise returns to organic farming are better than chemical farming, but there is a need to improve it significantly and on an enduring basis before organic cotton cultivation produces large-scale livelihood, productivity and environmental benefits. Likewise, in micro-irrigation farmers are benefiting by increasing their area under cotton by 2-3 acres and getting better prices for their produce, but still farmers' forays with micro-irrigation too are far from stabilized with new materials and methods under trial almost all the time. It will take more time and technical support for this experimentation to congeal and the most appropriate technologies to emerge and spread.

SECTION I: INTRODUCTION AND EVOLUTION OF THE RESEARCH

The Socio-Economic Photo (SEP) conceived in the Maikaal Research Project aimed at understanding the profile of adopters; adoption impacts; and the processes underlying the decision making of the farmers in the Maikaal region with respect to organic farming and micro irrigation technologies. SEP forms a part of the larger research project titled 'Growing Organic Cotton under Groundwater Stress' which also includes Agronomic Data Monitoring (ADM), Adoption and Dissemination Analysis (ADA) and other studies[1].

Towards this end, a large sample survey of 400 farmers was administered, besides measurements on farmer fields and trials on the bioRe research plot which largely aimed at comparing the results of different cropping systems. Further, several other studies also contributed towards enhancing our understanding of the socio-economic system in the study region and the process of farmers' decision making. These included, among others: [1] A detailed study on the spread, adoption and impact of *Pepsee* systems (Verma, Tsephal and Jose 2004); and [2] Two IRMA MTS studies on technology adoption and transfer dynamics of micro-irrigation in Maikaal, Saurashtra and Jalgaon (Singh and Jain 2003; Kumar and Sinha 2003). This report, therefore, presents a synthesis of several studies undertaken by IWMI broadly under the themes of Maikaal Research Project and Promoting Micro-irrigation in India.

Scope and Mandate of the SEP in the Maikaal Research Project[2]

While ADM seeks to deliver results on a system comparison between choices of different agricultural practices and their combinations; the SEP seeks to concentrate on the process part and tries to capture the significant variables in the decision making process that leads to selecting choices from available alternatives. Also, while the ADM provides in-depth and detailed results on the costs and benefits of the farming alternatives available for a smaller sample (100 farmers), the socio-economic photo would cover the breadth of the population by covering a much larger sample size (400 farmers). The also tries to capture the relevant developments over time in order to enrich and get a better understanding of the decision making process.

The SEP was therefore undertaken with the following main aims:

1. To compare Organic adopting with non-adopting households and drip / *Pepsee* adopting and non-adopting households on following parameters:
   - A. Farming Household Characteristic[3]
   - B. Material inputs and outputs
   - C. Monetary flow

[1] See Eyhorn *et al*. (2002) for the Detailed Research Concept
[2] Adapted from Eyhorn *et al*. (2002)
[3] The farming household characteristic will also aim to look at and analyze softer variables of socio-economics, space and inter-linkages within community.

2. To identify the profiles of typical organic adopters / non adopters and *Pepsee* adopters/ drip adopters / non-adopters in the Maikaal region; while also bringing in results and learning from studies in other (relevant) regions.

3. To study the adopters of the innovations for understanding their motivations for adoption.

4. To study the input linkages of organic agriculture /drips / Pepsee and the marketing strategies for promotion of organic agriculture and micro-irrigation.

Evolution of Research Hypotheses

Before we present the results of our studies, we think it would be useful to provide an overview of the way our hypotheses have evolved from the time of inception of the project. The project was conceived on the premise that a better understanding of the social, economic and ecological impact of organic production methods and low cost drip irrigation in cotton production would provide an insight into the mechanisms of the dissemination of these approaches.

The two key initial hypotheses for the socio-economic photo were (Eyhorn *et* al. 2002):

- Conversion to organic cotton contributes significantly to all-round improvement in the material well-being of the adopters; AND
- Water management adaptive innovations play a central role in helping the cotton economy cope with growing water scarcity in the region.

However, as the research progressed and our understanding of the two innovations and their impacts evolved, several new issues came up which were also examined. These are listed below:

- While the initial focus of micro-irrigation adoption was restricted to the adoption of drip irrigation and *Pepsee* systems, our analysis needed expansion to include several other water saving technologies, innovations and practices which were being adopted by the farmers in the region. These included, for example, the concepts of narrow and alternate furrow irrigation.
- The benefits of adoption of organic cotton went beyond individual household boundaries. There were some indirect impacts on the region as a whole which were also explored.
- In order to get a complete understanding of the farm economics of adoption, it was found imperative to include not only the cotton crop but the entire cropping system of the farmer. This was important because while bioRe offers a premium price and a host of extension services for the organic cotton produced; the farmers sell the other crops grown in rotation with cotton in the open market for which they usually do not get any price premium. Therefore, in parallel to the work on cotton, organic wheat trials were also introduced in the research. In recent years bioRe is trying to find organic markets for food crops to benefit the member-farmers and increase the business centrality of the members with the organization.

- Our initial understanding (or rather the lack of it) was that the organic material required to follow the prescribed practices was locally available in abundance, we soon realized that additional organic material needed to be produced on the farm and that organic farming practices foresee that organic matter is built up through a combination of optimizing crop rotation, intercropping, crop residue management, compost production, use of Farm Yard Manure (FYM) and supplemented by external inputs (if needed). This meant additional labor requirement for the organic farmers and therefore availability of family labor seemed to be an important variable for adoption.
- On the issue of micro-irrigation, our main concern was to understand how various technical innovations and mutations helped farmers adapt their cotton cultivation to groundwater and energy scarcity and to what extent did these help the farmers cope with these scarcities. While this was explored in detail, we noted a distinct possibility that at the current level of adoption, there actually will not be any 'real' water saving at the macro-level. This issue was therefore explored in detail during the studies.
- Just as the larger research project envisaged incorporating lessons from other organic projects, it was deemed necessary to incorporate results from experiences of micro-irrigation promotion from regions outside Maikaal to better comprehend the adoption behavior. For this, studies were conducted in Banaskantha (north Gujarat); Saurashtra (south Gujarat); Jalgaon and Dhule (Maharashtra).
- While we found it useful to explore where the two innovations were leading to in the overall scenario of the region, we felt that it was perhaps pre-mature to analyze the macro-level impact of the two innovations at this stage. While Maikaal bioRe represents the world's largest organic cotton project, the proportion of farmers associated with the project is still a small percentage of the total farming population. Even in the case of micro-irrigation, the adopters are few and far between. Thus, it is important to keep in mind the scale at which the two innovations currently operate. Having said that; there are some significant indirect impacts which the two innovations have already had on the socio-economy of the region; and the report tries to capture them to build a picture of how the scenario is likely to emerge in the years to come.
- Finally, the issue of high number of defaulting organic cotton farmers in the survey year and the growing spread of Bt cotton were significant changes that affected the organic farming part of the study.

We have tried to address all these issues in this report. Specifically, this report seeks to address the following questions:

1. What data and information have we collected?; How have we analyzed the data?; and What might be the limitations of our analysis? [Section II]
2. How has the socio-political dynamics in the region changed over the years, especially over the past few decades? [Section III]
3. Organic Farming: Adopters and non-adopters; economic and social impacts; and reasons for and hindrances to adoption [Section IV]
4. Micro Irrigation: Adopters and non-adopters; economic and social impacts; results from experimental plots and farmer field measurements; and reasons for and hindrances to adoption [Section V]

5. What has been the macro (meso) level impact of the spread of these innovations in the study area? [Section VI]
6. What lessons can we learn from the research? What issues need to be addressed in scaling-up the innovations within and outside the region? [Section VII]

SECTION II: METHODOLOGY AND DATA COLLECTION

II.1 Diversity and Interference

Farming conditions in the Maikaal region[4] (as in most places) are not common across farmers and there are a lot of variables that could possibly affect farm outputs and technology choices. Even within the small area which we have studied, there are two very different sub-regions (Narmada Belt and Upland Areas) which have different resource conditions in terms of soil and water availability. Moreover, the farming community itself is not homogenous and displays a wide spectrum of ethnos. On the one extreme, we have the *patidar* migrants from Gujarat who are well-known for their enterprise and farming skills. Co-existing with them are tribal communities that have traditionally not been farmers and used to (and in some cases still continue to) depend largely on forests for their livelihoods. These two extremes are co-habited by a large number of communities with varying degree of experience, exposure and skills in farming. This factor itself sometimes becomes a determinant of farm output which is difficult to capture and almost impossible to quantify. The soil conditions also are variable and in certain cases, the soil changes from heavy to light within the same plot of land.

We also faced significant interference problems while trying to understand the differences between adopters and non-adopters of both the innovations. In the case of water-saving technologies, we found that narrow and alternate furrow irrigation was being practiced by a large majority of the farmers in the region. Thus, there were hardly any flood irrigators in our sample to compare with drip irrigators. The control population in the region has been strongly influenced either by the adopters of water saving technologies or by the recurrent drought conditions. At the same time, we found that a large number of the drip adopters used the innovations only for pre-monsoon sowing and reverted back to furrow irrigation in the post-monsoon season. This meant that not only were the non-adopters behaving, in certain sense, like the adopters; even the adopters were not using the technologies throughout the year. Normally when drip adopters and non-adopters are compared, non-adopters are gravity/flood irrigators who do not use any water saving technologies/practices (Narayanamoorthy 1999; Sivanappan and Padmakumari 1980; Sivanappan 1977; Muralidhara *et al*. 1994). However, in our case, this was not so.

Even in the case of organic farming, poor monsoons, high indebtedness, influence of bioRe extension services and the demonstration effect of organic farmers in the region has changed the practices of chemical farmers indirectly. A large number of them have reduced their application of chemical inputs. This left us comparing the organic with the 'pseudo-chemical' farmers. So, while these farmers continue to use chemical inputs (and therefore can not be termed organic or even natural farmers), their chemical-use rates have come down. In addition, as we already mentioned above, roughly 40% of the bioRe farmers were found to be defaulting on adherence to organic practices and were excluded from the Maikaal project in the survey year.

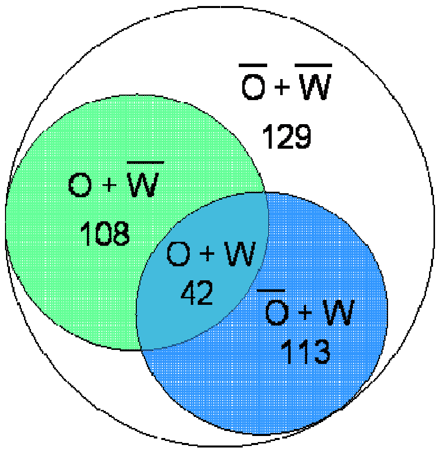
[4] 'Maikaal Region' is not to be confused with 'Maikaal Fibres Ltd.'. Maikaal is the name of the hill ranges which boundary the study area in the east. Therefore the name of the region as well as (perhaps) the company.

Some of these bioRe defaulters; as well as defaulting farmers associated with two other private companies in the region (from whom we could not obtain a list or even an estimate of proportion of defaulters) were included in our sample. This weakened our comparisons between adopters and non-adopters.

Studies and Sampling Plans

The sampling of 400 farmers for the SEP survey was done using purposive sampling technique. Broadly, if we divide the farmers into organic adopters and non-adopters; and micro-irrigation adopters and non-adopters, the following numbers emerge:

Figure 1: Sampling Plan for the 392-farmer SEP survey



O = Organic Adopters; $\overline{O}$ = Organic Non-Adopters;

W = Micro Irrigation Adopters; $\overline{W}$ = Micro Irrigation Non-Adopters

The survey was undertaken for a period of four months beginning from July 2003 to November 2003. Four local surveyors were hired to survey 400 farmers from 45 villages. Villages were chosen such that there was a proper representation of villages from the Narmada belt as well as villages in the upland areas. Some organic farmers not under bioRe were also surveyed.
During the course of the survey the surveyors faced a number of problems. The problems were related to data regarding crop economics for previous years as well as data regarding debt taken by the farmers. Many of the farmers refused to answer questions which they thought were offensive. Also there were problems of farmers overstating their costs and understating their yields. Also since the data was based on recall there were a number of irregularities in the data sets. After removing the irregularities, from the sample of 400 farmers, a smaller dataset was extracted having data across all the parameters required for analysis.
Besides the 400 sample SEP survey, there were also three more surveys conducted in Maikaal. The first one (Verma, Tsephal and Jose 2004) was undertaken specifically to explore the various aspects of the *Pepsee* systems, its history and spread, to make a comparative technical/financial evaluation of *Pepsee* with conventional drip/micro-tube and flood irrigation technique, to analyze the conditions

and factors that lead to successful adoption of *Pepsee* systems and finally to suggest a marketing strategy for replication of the technology. The sample for this survey was 180 which included farmers from Maikaal (West Nimar) as well as Jalgaon. This sample was totally different from the sample of the SEP survey and this survey was carried out in 2002. The sampling plan for this study is given in Table 1. The study also involved semi-structured interviews with manufacturers and retailers of *Pepsee* systems and drip irrigation systems in both the regions.

Table 1: Sampling Plan for farmer surveys for the study on *Pepsee* systems

Segment	Size					
	Maikaal		Jalgaon		Total	
	Planned	Actual	Planned	Actual	Planned[5]	Actual[6]
***Pepsee* Adopters**	30	27	30	27	**60**	**54**
Drip Adopters	30	19	30	21	**60**	**40**
Non Adopters	30	30	30	33	**60**	**63**
Total	**90**	**76**	**90**	**81**	**180**	**157**

A second study (Singh and Jain 2003), which focused on adoption dynamics of drip irrigation and followed a methodology of in-depth interviews, focused group discussions and case studies, was conducted in three regions: Nimar Valley (Maikaal), Jalgaon and south Gujarat. The sampling plan for this study is given in Table 2.

Table 2: Sampling Plan for the study on Adoption Dynamics of Drip Irrigation

	Adopters	Non-Adopters	Total
Jalgaon	20	10	**30**
Maikaal	20	10	**30**
Saurashtra (south Gujarat)	20	10	**30**
Total	**60**	**30**	**90**

Another study (Kumar and Sinha 2003), focusing on understanding the various stages of technology transfer in the case of drip irrigation, was conducted in Maikaal, Saurashtra and Nashik. The sampling plan for the farmer interviews in this study is given in Table 3. Besides the farmer interviews, interviews were also conducted with manufacturers, wholesalers and retailers, especially in Nashik.

Table 3: Sampling Plan for the study on Technology Transfer Models

	Adopters	Non-Adopters	Total
Nashik	15	15	**30**
Maikaal	30	15	**30**
Saurashtra (south Gujarat)	15	15	**30**
Total	**60**	**45**	**90**

Note: The regions outside Maikaal which were covered in these studies have some similarities and differences. The similarity is in the fact that all these regions represent areas where micro-irrigation is becoming a popular choice among farmers, just as in Maikaal. Other commonalities between the regions (and also Maikaal)

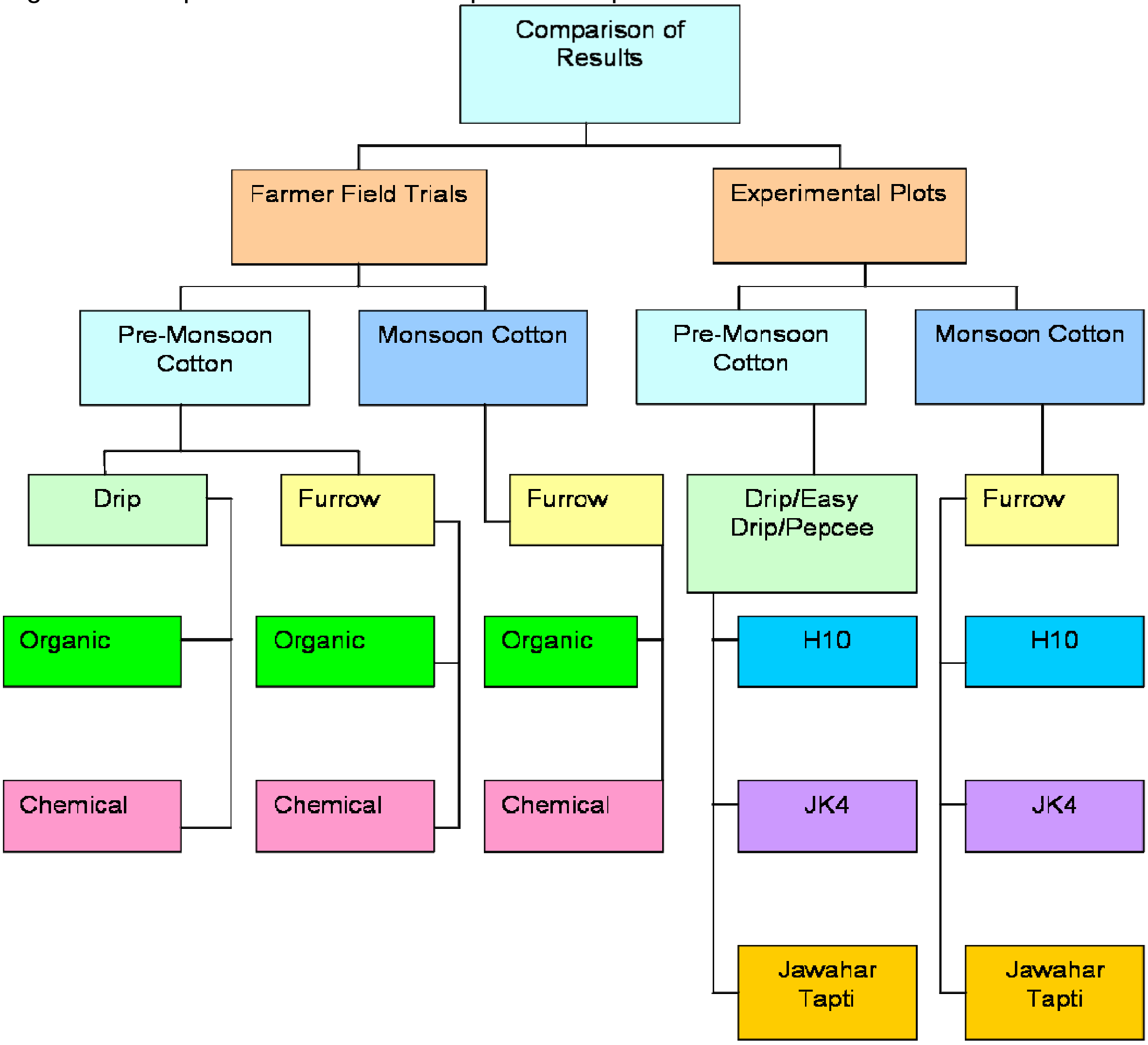
[5] Number of respondents approached with the questionnaire
[6] Number of complete questionnaires actually used for analysis

include predominance of groundwater irrigation, declining water tables and growing difficulty in access to fresh water for irrigation[7]. However, the cropping patterns and agronomic conditions in the regions differ. Nashik and Jalgaon are pre-dominated by horticulture; cotton is the main crop in Maikaal; and Saurashtra is dominated by groundnut cultivation.

Plot trials were also conducted in the bioRe experimental plots and measurements were made in the fields of 12 farmers in Samasthipura village. The main aim of these studies was to compare the differences in water application to cotton in the experimental plots (under controlled conditions) and in the farmer fields which are affected by various factors. The next level of comparison was between pre-monsoon and monsoon cotton, both in the experimental plots as well as the farmer fields. It was also decided to compare the water application under different systems of irrigation i.e micro-irrigation and furrow irrigation in the experimental plots and farmer fields. In case of the experimental plots comparison was also made between the different variants of the micro- irrigation systems like Pepsee, Easy drip and Conventional drip and also on the varieties of seeds (H8, Jawahar Tapti and JK4).

[7] In the case of Maikaal, Jalgaon and Nashik the difficulty arises from depleting groundwater aquifers while in the case of Saurashtra, the issue is of poor quality (salinity) of groundwater.

Figure 2: Comparison of results of experimental plots and farmer field trials



There were five organic farmers and seven chemical farmers in our sample for farmer field measurements. Out of the five organic farmers four farmers practice pre-monsoon farming with drip irrigation while one of the farmers practiced pre-monsoon farming using drip as well as furrow irrigation. Out of the seven chemical farmers, there is one farmer doing pre-monsoon farming with drip irrigation; five farmers doing monsoon farming with furrow irrigation; and one farmer doing practicing both pre-monsoon and monsoon farming with furrow irrigation (Table 4). The results of these studies are also discussed in this report.

Table 4: Sampling plan for Farmer Field Trials in Samastipura

Type of Farming	Type of Irrigation	
	Drip Irrigation	Furrow Irrigation
Pre-monsoon/Organic	5	1
Pre-monsoon/Chemical	1	1
Monsoon/Organic	-	-
Monsoon/Chemical	-	6

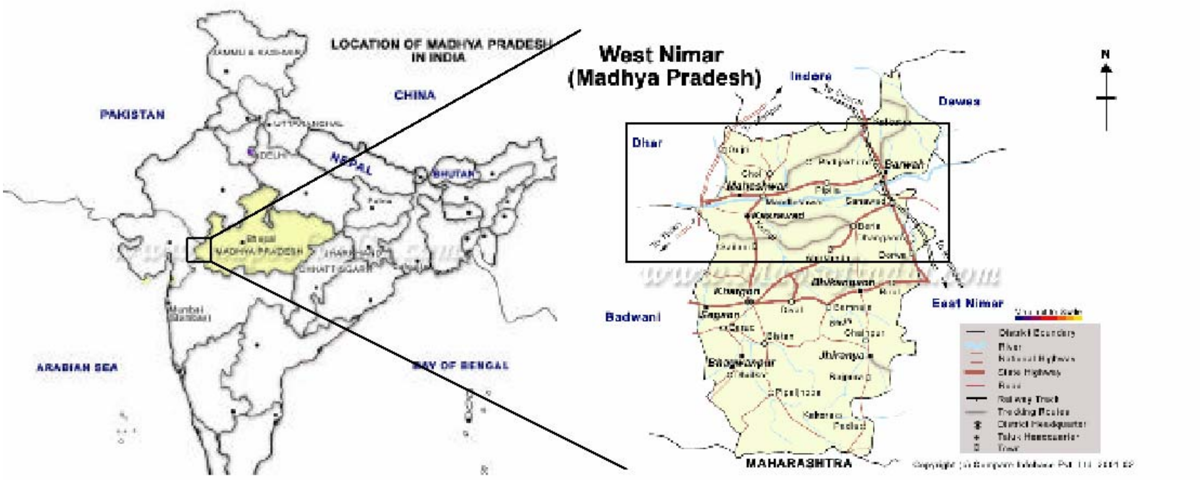
Finally, building upon the preliminary literature review done for the research concept, a comprehensive review of literature and recent evidence on mass promotion of micro-irrigation in India was undertaken (Verma 2004).

SECTION III: SOCIO-POLITICAL DYNAMICS IN MAIKAAL

III.1 Overview of the Study Region

The project area is part of the erstwhile *Nimar* (and later *West Nimar*) district, with its headquarters at *Khargone*. It is the south west extreme of Madhya Pradesh and borders Gujarat and Maharashtra. It is located between the latitude 21° 22' North and 22° 35' North. Physically the district is a central section of the Narmada valley with the bordering Vindhyan scarp in the North and the Satpura ranges in the South. Nimar has been a seat of cultural intermixing and exchange for a long time and has, at different times, been ruled by the Haihayas of Mahismati, Parmars of Malwa, Shahs of Gujarat, the Mughals, Nizam of Hyderabad, Peshwas and the Holkars, amongst others.

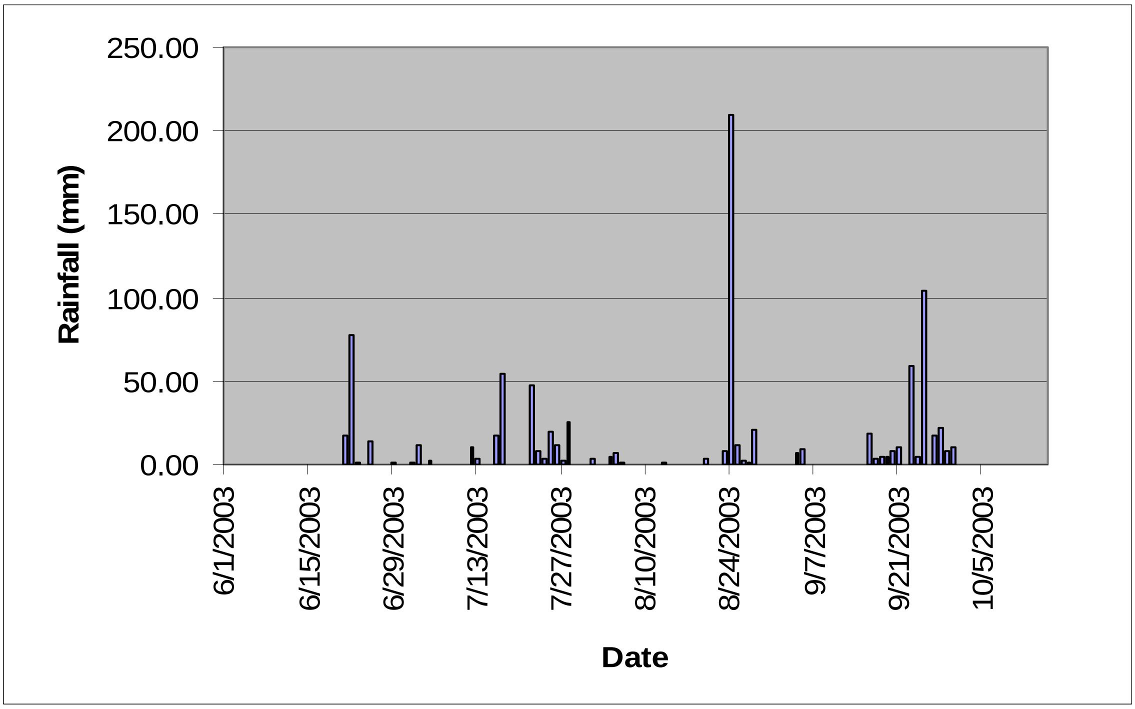
Figure 3: Location of the Maikaal Region



The Narmada River, known as the lifeline of Madhya Pradesh, is the fifth largest river in India and the largest west flowing river of peninsular India. The Vindhya Mountains in the north, Satpura ranges in the south and the Maikaal ranges in the east form the boundaries of Narmada basin. The drainage map of Narmada basin is given in Figure 3.

The rainfall in the region has been very erratic from year to year, place to place and also within a given crop season. This can be seen from Figure 4 where we see that in August and September there was a heavy rainfall of 200 mm and 100 mm respectively in a single day. This greatly affected the pod formation of the pre-monsoon crop which eventually had lower yield as compared to monsoon crop, in the first flush.

Figure 4: Rainfall for the year 2003 at the bioRe farm



Source: bioRe records

A detailed description of the geography, climate, population, soils, agro-climatic conditions, crops, farm activities and irrigation scenario of the region has been provided in the Detailed Research Concept of the Maikaal Research Project (Eyhorn *et al*. 2002).

III.2 Changes that Shaped the Present

Nimar Valley at the time of Independence: Part of the 'Central Provinces' under the British rule, the Nimar valley was pre-dominantly an agrarian economy at the time of independence. While wheat dominated agriculture in the rest of Central Provinces, this region has traditionally been a Cotton growing area, along with Nagpur and Wardha districts of Maharashtra. The farming was largely rain-fed and the only rare irrigation facilities were non-motorized. Rabi cultivation was minimal and totally dependent on late October rains. Cotton and Groundnut were the main cash crops. Among cereals, sorghum was important as the staple diet of the region and the area under sorghum was steadily increasing.

Genesis of Irrigated Agriculture in the Region: Rajasthani-speaking immigrants from central and western India were probably the first to introduce the local inhabitants to the concepts of settled agriculture. As the pressure on land grew, it forced people to clear more land for cultivation. The possibility of intensifying land-use through the cultivation of Rabi crops emerged around the mid-1950's with Wheat replacing the traditional Bajra crop. This process received a significant boost with the launch of the Intensive Cultivation of Cotton, Groundnut and Jowar (ICCGJ) Project by the government in 1963. The intervention actively supported the use of both inorganic and organic manures to maximize the yields of these crops. While chemical fertilizers were first introduced in the area way back in 1952, the initial uptake was low and farmers preferred to continue with manure and compost. However, as a result of the ICCGJ project and with the provision of assured irrigation and improved access to markets, the preferences of farmers gradually shifted in favor of chemical fertilizers. The new system of farming delivered quick results and the *patidar* farmers of the region were quick to adopt the new practices. By around the mid-1970s, this new system of farming became the order of the day with even the small-holders adopting these practices.

Continued Intensification: As the farming system changed, it also brought about changes in the political economy of the region. Whereas land was the dominant source of political power in a subsistence oriented agriculture economy, gradually new sources of social power such as water control (access to reliable irrigation) and capital (ability to invest large amounts of working capital in farm inputs) emerged. In the 1980's, the Nimar farmers were first exposed to the utility of pumping technology to lift water directly from the Narmada River and carry it to their fields through pipelines. This further deepened the divide amongst the *have's* and the *have-not's* and also between the Narmada belt and the upland areas. The valley soon became the centre of a quiet agricultural revolution brought about by the green revolution technologies and the farmers in this region, mostly *patidars* who had migrated from Gujarat centuries ago, developed a rich and vibrant agriculture based economy in the whole of Nimar valley. The farmers progressively intensified inputs-use to enhance yields and soon the cotton farmers of the region were among the highest consumers of fertilizers and pesticides in the country. Of the total pesticides used in agriculture in India, 54% is used in cotton cultivation. This is despite the fact that cotton cultivation accounts for a mere 5% of the total land under cultivation (Puri *et al*. 1999). The Indian cotton farmers spend as much as Rs. 2500 crore on pesticides every year. This is not unique to Indian cotton farming, though. Globally, more than 10% of all pesticide use (amounting to roughly US$ 2.6 billion) and 25% of all insecticide use comes from cotton farming (Mennon 2003). This pattern continued almost un-abated until about a decade ago when irrigation constraints, evident in the declining water levels; poor rainfall; and degrading soil and land properties lead to successively falling cotton yields, declining proportion of area under irrigation, increase in debt accumulation and reduced purchasing power of farmers.

Maikaal bioRe: In 1992, Maikaal bioRe (I) Ltd. offered 'Organic Agriculture' as an alternative system of farming to the conventional cotton farmers based on the use of agro-chemical inputs of the region. The project offered multiple services to the member-farmers including a premium pricing for the organic cotton produced and extension support services to facilitate the process of conversion. The organic movement in the Maikaal region has now become much larger than bioRe itself Two more organic promoting projects have emerged: Pratibha Syntex and Mahima Organics at Karahi and Manawar respectively. In 1994, the Maikaal project recruited a team of 7 extension officers, 7 supervisors and one coordinator, forming 7 farm centres: Kasravad, Pipalgone, Maheshwar, Mandleshwar, Dawana, Nimrani, Balakwada. Today, bioRe has 10 such centres all over the region.

The role of the extension officers and supervisors is to train and advice the farmers in organic cotton production; to implement the internal control system (regular field visits and inspection according to the agreed standards); to organize distribution of farm inputs and collection of organic cotton; and to establish mutual exchange of information between the farmers and the project.

Genesis of Micro-Irrigation in the Region: In the 1990's, Micro-Irrigation technologies penetrated into West Nimar and its adjoining districts though the intervention of International Development Enterprises (IDE) and through the informal channel of word-of-mouth. IDE began its work with bioRe and encouraged bioRe's member farmers to experiment with their micro-tube technology for drip irrigation. Almost around the same time, some progressive farmers had already begun trying out the drip irrigation technology for cotton cultivation which they brought from neighboring districts of Maharashtra. For various reasons, IDE moved out of the region; however, the seeds of water-saving it had sown there have blossomed and borne fruit (Shah and Keller 2002; Verma *et al*. 2004).

***Pepsee* Systems:** While bioRe continues to promote IDE's low-cost micro-tube kits, even these are too costly for many farmers who are apprehensive about the technology or sometimes incapable of making the initial investments of Rs. 7000-8000 per acre[8]. The recurrence of drought like situation in the region for the last one decade has worsened the problem of rapidly depleting groundwater resources and low purchasing power of farmers, compelling many farmers to look for an alternative less expensive technology which not only enables them to take a summer crop with less water but also increases irrigation-water-use efficiency and land productivity. A lot of innovations were going on at the grassroots level to bridge the gap between technology and cost factor. Innovations like using cycle tubes for drip irrigation etc. were carried out by farmers in some parts of Madhya Pradesh and Maharashtra. But these innovations were confined to a limited area and most of them failed to catch-on, as they were not able to deliver the desired results. Around 1998-99, a new innovation called *Pepsee* came up in this area. It is not very clear how and exactly where the innovation first started but there did exist a very strong, though latent, demand for a low cost water saving technology in the entire region for a long time.

Figure 5: The 'White' and 'Black' *Pepsee* in use

[8] bioRe offered a interest-free loan scheme for micro-irrigation where the farmers themselves decide the pay-back installments and the money gets automatically deducted from payments due to them for the cotton procured. This scheme seems to be extremely popular with the farmers and we found farmers demanding that bioRe should give them more drip under this scheme. bioRe offered drip-kits for 1 acre plot size under this scheme.

Small candy manufacturers use light density plastics, disposable in nature to fill ice candies which are sold as "*Pepsee*" in the local markets. The plastic candy is transparent in nature and comes in a length of 20 cm. The candy manufacturers buy these plastics in continuous rolls and then the roll is divided into small lengths to make ice candy. The cost of the plastic rolls comes to around Rs. 50-55 for the manufacturer and Rs. 65-80 per Kg for the farmer. This plastic roll is today being used in place of the drip tubes and is placed directly at the root zone of the plants. Water is applied through these plastic pipes and reaches the plant roots through small holes pierced in the pipes at regular intervals. The entire system is assembled locally and does not require high order of skill to prepare. The farmers started using the *Pepsee* system for irrigating cotton crop during pre monsoon season. Two years ago, a recycled-plastic version of the *Pepsee*, popularly known as Black *Pepsee* came into the market. The farmers distinguished the earlier transparent product and it came to be known as White *Pepsee*. The Black *Pepsee* is cheaper and also removes the problem of algae attack which was a major trouble with the earlier product. In the initial years, word of mouth was the main source of spread. As there was a strong latent need for low cost water saving, the news about the new innovation spread among farmers like wild fire. In 2001, IDE India has recognized the success of this grassroots innovation and has introduced its own version of the *Pepsee*, aptly named 'Easy Drip'.

SECTION IV: ORGANIC FARMING

In this section, we look at: [1] the profile of the adopters and non-adopters; [2] economic and social impacts of adoption of organic farming; and [3] reasons for and barriers to adoption.

IV.1 Profile of Organic and Chemical Farmers

In this section, we look at the profile of organic and chemical farmers. We try to identify how the adopters of organic farming are different from the non-adopters on parameters such as land holding; indebtedness; centrality and yields of cotton; labor availability; organic inputs availability; and water control.

Table 5: Profile of adopters and non-adopters

[a] LAND HOLDING

Parameter	Organic	Chemical	F-Statistic	Sig.	Sample Size		
					Organic	Chemical	Total
Avg. Land Holding	13.26	12.11	0.46	0.49	70	96	166
Avg. Gross Cropped Area in a Year	12.99	10.71	2.49	0.11	70	96	166
Cropping Intensity	1.44	1.35	2.53	0.11	70	96	166

[b] INDEBTEDNESS

Parameter	Organic	Chemical	F-Statistic	Sig.	Sample Size		
					Organic	Chemical	Total
Avg. Value of Debt (past 3 yrs.)	13836.76	14465.48	0.02	0.88	85	126	211
Avg. Value of Debt per Acre	3944.88	7454.46	2.67	0.10	85	126	211

[c] CENTRALITY AND YIELDS OF COTTON

Parameter	Organic	Chemical	F-Statistic	Sig.	Sample Size		
					Organic	Chemical	Total
Land under Cotton per Household	6.09	5.45	0.94	0.33	70	96	166
Proportion of Land under Cotton	0.69	0.54	2.39	0.12	70	96	166

[d] LABOR AVAILABILITY

Parameter	Organic	Chemical	F-Statistic	Sig.	Sample Size		
					Organic	Chemical	Total
Land-Man Ratio	3.30	3.22	0.05	0.82	65	120	185
Avg. Annual Expenditure on Hired Labor per Acre	834.09	1097.97	1.12	0.29	73	109	182
Labour Man-Days in the field	1020.92	1101.53	0.94	0.33	99	191	290

[e] WATER CONTROL

Parameter	Organic	Chemical	F-Statistic	Sig.	Sample Size		
					Organic	Chemical	Total
Well Density per 100 Acres	12.01	10.35	1.02	0.31	58	124	182
Tube-well density per 100 Acres	2.19	2.65	0.32	0.56	58	123	181
Number of months in a year when water is available for irrigation	9.63	8.68	4.37	0.03	85	138	223

[f] AVAILABILITY OF ORGANIC INPUTS

Parameter	Organic	Chemical	F-Statistic	Sig.	Sample Size		
					Organic	Chemical	Total
Avg. Number of High Foliage Trees per Acre in 2002	3.11	2.25	1.42	0.23	95	190	285
Avg. Number of High Foliage Trees per Acre 5-10 yrs. Ago	0.22	0.26	0.29	0.58	95	190	285
Avg. Number of Cattle per Acre	0.96	0.74	5.64	0.01	108	185	293
Avg. Daily Dung Availability (Kgs.)	56.13	72.71	3.46	0.06	53	46	99
Avg. Availability of Agricultural Waste (Trollies)	2.11	1.65	3.32	0.06	111	183	294

SEP survey (2003)

[g] ECONOMIC WELL-BEING

Parameter	Adopter Farmers	Non-Adopter Farmers
Kitchen Expenses (> Rs. 1000 p.m.)	68.20 %	61.50 %
Household Expenses (> Rs. 1000 p.m.)	63.30 %	59.70 %
Education Expenses (> Rs. 500 p.m.)	34.00 %	27.80 %
Hostel Education	42.60 %	32.10 %
Incidence of Migration	0.00 %	1.60 %
Outstanding Debt Liabilities	61.30 %	69.00 %
Sufficient Food Availability	100.00 %	96.20 %

SEP survey (2003)

Table 5 provides an overview of the Organic adopter and non-adopter profiles. Based on the data above, we summarize some important points:

- Our initial hypothesis was that farmers having small to medium landholdings would opt for organic farming, since organic farming is a low external input system of farming. But we found that average land holding was higher for organic adopters. The differences in means were however not found to be significant. In the initial years of introduction of organic farming, it was largely the large farmers who joined bioRe. This, however, seems to have been diluted and in the later years, as the bioRe extension team also pointed out, small and medium farmers also joined and this explains the lack of difference between the two groups.

- Cropping Intensity is defined as the ratio of the total cropped area in a year (including both Kharif and Rabi) to the total cultivable land holding. We did not find significant difference in means of Cropping Intensity between the organic and chemical farmers. Organic farmers have higher cropping intensity compared to the chemical farmers. This could be attributed to the fact that the adopters of organic farming are also the ones who have better water control and availability.

- The average value of debt (for the past three years) as well as value of debt per capita and per acre was found to be hlower for organic farmers, though the difference is not significant.

- The centrality of cotton in agriculture has been calculated as the ratio of land under cotton to the gross cropped area[9]. This was calculated to compare how central is cotton to the cropping system of farmers. Going with our initial hypothesis, we found that this ratio was higher (though not significant) for organic farmers.

- Another of our hypotheses was that households with lower land-man ratio (acres of land-holding/number of adult family members in the household) would be more likely to choose organic farming. This is because the reduction in input costs, which is a major driver for organic adoption, would be more for families which can substitute the capital intensity of chemical farming by investing more labor from within their household. This was found to be true and further reinforced by the lower expenditure on hired labor per acre for organic farmers. Though, again, the differences among the groups were not found to be significant.

- Our indicators for organic inputs availability, except one, show higher values for organic adopters. This is quite obviously to be expected. Experience in north Gujarat (Singh and Kishore 2004) as well as recent field visits in Kolar (Verma and Ghosh 2004) indicates that water scarcity induces farmers to shift away from agriculture and towards dairying. As water scarcity becomes more critical and area under irrigation reduces, farmers tend to depend more and more on dairying incomes as these incomes have shorter operating cycles (time between input investment and return availability). We believe that the same is happening in Maikaal as well and that farmers with higher centrality of dairying in their livelihoods (and therefore more livestock; more dung availability) would more easily convert to organic farming. However, we find it difficult to explain the lower availability of dung for organic adopters even when the average number of cattle is higher. One of the reasons for this sort of finding is that there is huge demand for dung for the working of the bio-gas plants, which are prevalent in the villages. Also, interestingly, our recall-based data suggests that the average number of high foliage trees per acre has gone up significantly, not only for the organic adopters (from 0.23 to 3.11) but also for the non-adopters (0.26 to 2.26).

- Another important observation from the data was that the proportion of area under soya crop is rising in the case of organic farmers. This is probably because soya, being a leguminous plant, is less prone to pest attack and does not require

[9] Gross Cropped Area (GCA) is the total area cultivated during the entire year. If a farmer has 10 acres of land and he cultivates 8 acres in Kharif; 5 acres in Rabi and 2 acres in summer, the GCA would be 15 (8+5+2) acres.

a lot of chemical inputs. bioRe's promotion of diversifying crop rotation and recommendation to include leguminous crops could have played an important role in this development. With lesser chemical input requirements, Soya cultivation is also in line with the low-cash-input farming practiced by the organic farmers.

- Water control is defined as access to reliable irrigation. For this, we looked at three parameters: Well Density; Tube-well Density and the number of months for which water was available in the wells/tube-wells (Note: groundwater irrigation is the dominant mode of irrigation in the region). We found that there was not much difference between the two groups in the case of well density and tube-well density. But there was significant difference in terms of the number of months of availability of water. The organic farmers also enjoy better access to water in terms of the number of months of availability (there is negligible differences in the capacity of pumps with 5 HP being the modal value).

- A grater proportion of adopters reported Household Kitchen expenses in excess of Rs. 1000 per month and expenses on Education to be in excess of Rs. 500 per month. A greater proportion of adopters reported to have their children studying in hostels or residential schools outside their village. Significantly, while the proportion of households migrating outside their village is generally quite low (less than 1%), none of the adopters reported to have any experience of migration, either willing or forced, over the last three years. The adopters also reported fewer cases of outstanding debt liabilities compared to the non-adopter households. Also significantly, all adopter households reported sufficient food availability throughout the year and all of the 1% households which reported the lack of sufficient food throughout the year were among the non-adopter households.

IV.2 Economic and Social Impacts of Adoption

ECONOMIC IMPACTS

Out of the total sample of 400 farmers, we extracted a smaller sample of 170 farmers (after excluding incomplete data-sets; bioRe defaulters in 2003; and outliers) to compare the crop economics in the production of cotton for organic and chemical farmers. The results of this exercise are presented in Table 6.

Figure 6 shows the trend in prices of top-grade cotton in Kasrawad market in the year 2003. The sharp rise and fall in prices is crucial and makes the time of selling cotton a crucial variable in the crop economics of cotton for a farmer. The first flush of pre-monsoon cotton is harvested between 1 September and 30 October and the second flush is harvested between 1 January and 15 February. This is the time when the price of cotton in the market is at its peak. On the other hand, the first flush of monsoon cotton is harvested between 1 November and 30 December and the second flush is harvested between 15 February and 15 March. At these times, the prices in the market are lowest.

Figure 6: Trend in top-grade cotton prices in Kasrawad market in 2003

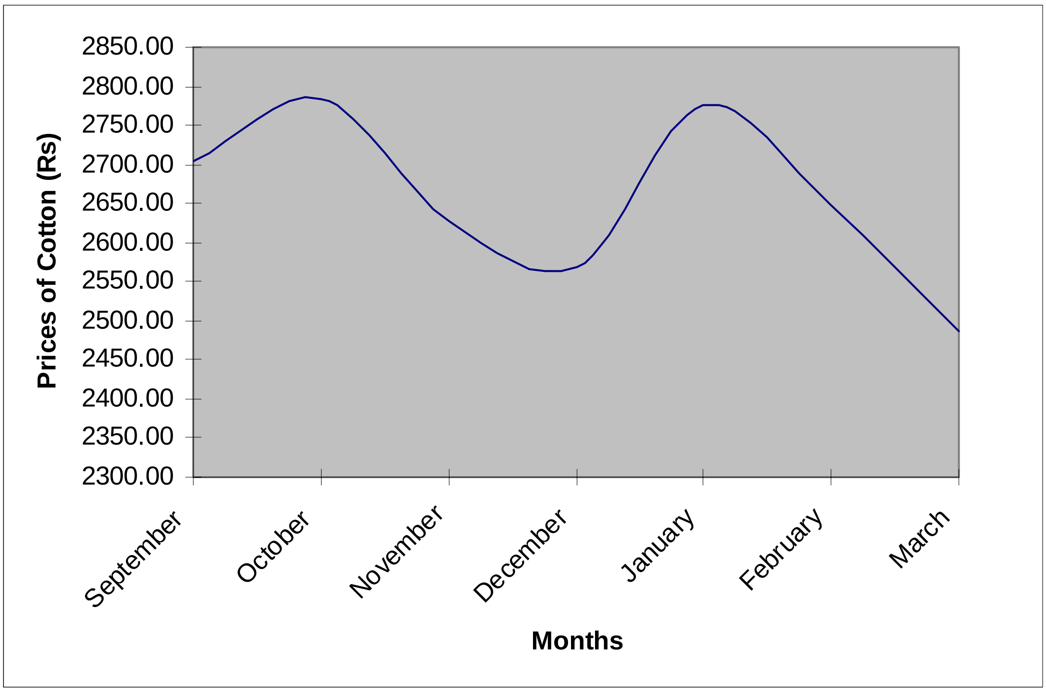


Table 6: Comparative Cotton Crop Economics for Organic and Chemical Farmers

	Parameters	Organic		Chemical	
[1]	Sample Size	68		102	
[2]	Average Land under Cotton (Acres)	6.38		4.72	
[3]	Average Seed Cost (Rs/Acre)	541.98		622.42	
[4]	Average Fertilizer Cost (Rs/Acre)	0.00		1020.13	
[5]	Average FYM Cost (Rs/Acre)	2128.94		1682.65	
[6]	Average Pesticide Cost (Rs/Acre)	184.36		230.25	
[7]	Average Labour Cost (Rs/Acre)	745.46		829.68	
[8]	Average Production Cost (Rs/Acre)	3600.74		4385.13	
[9]	Average Yield per Acre (Quintals/Acre)	4.17		4.08	
		Pre-Monsoon	**Monsoon**	**Pre-Monsoon**	**Monsoon**
[10]	Average Market Price (Rs./Quintal)	2764.55	2569.51	2764.55	2569.51
[11]	20% Premium (Rs/Quintal)	552.91	513.9	0.00	0.00
[12]	Average Price Received (Rs/Quintal)	3317.46	3083.41	2764.55	2569.51
[13]	Average Total Revenue (Rs./Acre)	13833.81	12857.82	11279.36	10483.60
[14]	Average Profit (Rs/Acre)	10233.07	9257.08	6894.23	6098.47
[15]	Weighted Average Profit (Rs/Acre)	9702.02		6309.11	

SEP survey (2003)

The crop economics table and the data on market prices in Kasrawad in 2003 provide critical insights into the dynamics of cotton cultivation in Maikaal. We briefly discuss the results below:

- In our (cleaned) sample, organic farmers have larger land area under cotton. Though we have seen above that the differences in means are not significant, in this sample, the differences seem to show much more glaringly.

- The average per acre expenditure incurred by organic farmers is much lower vis-à-vis chemical farmers. This is true for seed costs, fertilizer costs, pesticide costs, and even labor costs. The only costs which organic farmers incur more than their chemical counterparts is the cost of farm yard manure (FYM). The average total production cost per acre for a organic farmer is roughly 20% lower compared to the costs per acre incurred by chemical farmers. The low production cost along with the 20% premium on organic cotton is the prime reasons for the higher profit margins for organic farmers. This is one of the main reasons for farmers taking to organic farming in the region.

- The average yield per acre is also slightly higher for the 68 organic farmers in our sample. Though, we have seen above from the data for the entire sample that the yield differences are not significant.

- Our sample of 68 organic farmers, 31 farmers are drip adopters. Out of the 102 chemical farmers, 27 are drip adopters. We have assumed that all the 58 drip adopters take pre-monsoon cotton and have broken up the prices received by the farmers according to average market prices in the market for pre-monsoon and monsoon cotton. This is, the average prices for pre-monsoon cotton were calculated by taking the average prices of cotton for the period of 1 September to 30 October, which coincides with the first flush of pre-monsoon cotton and 1 January to 15 February which coincides with the second flush of pre-monsoon cotton (average price/quintal for pre-monsoon cotton: Rs. 2764.55). The average prices for monsoon farmers were calculated by taking the average prices for cotton for the period 1 November to 30 December and 16 February to the last harvest of the cotton crop (average price/quintal for monsoon cotton: Rs. 2569.51). On the basis of these, we have calculated figures for row [12].

- We find that in either case (monsoon or pre-monsoon), organic farmers get higher actual prices compared to organic farmers. Moreover, since the average yields of organic farmers are (slightly) higher, consequently, their total revenues are also higher. Also, since they incur roughly 20% lower costs, their net profits are also higher.

- We tried to check, whether this trend is a common phenomenon in the region, by looking at the average monthly prices for cotton in the Kasrawad market for the last seven years (from 1995-96 to 2003-04). Similar trend is seen in two of the last nine years. But it would be wrong to state that this trend will remain for the future years, as prices of cotton depend on a number of factors and competitive markets try to remove any irregularities over time.

- On the basis of proportion of drip (pre-monsoon) farmers in each of the sample groups (organic and chemical), we estimated the weighted mean profits per acre for organic and chemical farmers. We found that, (on an average), the net profit of organic farmers is more than 50% higher compared to the chemical farmers.

- We also calculated the actual percentage premium (difference) between the four category of farmers: Organic-Pre-Monsoon; Organic-Monsoon; Chemical-Pre-Monsoon; and Chemical-Monsoon. The results are shown in Table 7 below. We see that while all organic farmers receive a flat 20% premium, those who take pre-monsoon cotton receive prices which are as much as 30% higher compared to chemical farmers taking monsoon cotton crops. On the other hand, organic farmers taking monsoon cotton get only 11% higher prices compared to chemical farmers taking pre-monsoon cotton. This perhaps explains the discontentment among some of the farmers we interviewed about not actually getting a full 20% premium!!

Table 7: The impact of pre-monsoon sowing on premiums

		Organic		Chemical	
		Pre-Monsoon	**Monsoon**	**Pre-Monsoon**	**Monsoon**
Organic	**Pre-Monsoon**	0.00	7.59	20.00	**29.11**
	Monsoon	-7.06	0.00	**11.53**	20.00
Chemical	**Pre-Monsoon**	-16.67	-10.34	0.00	7.59
	Monsoon	-22.55	-16.67	-7.06	0.00

SEP survey (2003)

Therefore, we see that as far as the crop economics of cotton crop are concerned, organic farmers are much better-off compared to the chemical farmers. However, while calculating the crop economics in the section above, we have assumed that the quality of the cotton produce is the same for all the 170 farmers in our sample and have used the market prices of top-grade cotton. This will not be the case for all the farmers. Our discussions with farmers as well as references in literature (see, for instance, Kale 2003) indicate that organic farmers get lower grading while selling their produce in the market. The SEP, however, did not collect data on this aspect in the survey conducted. Also the harvesting period of cotton may vary from farmer to farmer. It may vary for both pre-monsoon as well as monsoon farmers, depending on which the prices received by these farmers may also, vary. The SEP, however, also did not collect data on this aspect in the survey conducted.
Given the above assumptions organic farming is definitely a better proposition for farmers in the region as compared to chemical farming. Even though the adopter profile did not show differences in average debt among the organic and chemical farmers, the fact that organic farming is a low input-low output-higher profit system to the farmer as compared to chemical farming indicates that organic farming is a less riskier proposition for the farmer as compared to chemical farming.

SOCIAL IMPACTS AND ‘SOFT’ VARIABLES

Even among the adopters of organic farming, there are different degrees of adoption among farmers. Initially most of the farmers who adopt organic farming do it for the economic benefits, but as the farmers realize the other benefits of organic farming they start perceiving the principles of organic farming as a part of their lives. As they start buying in the organic philosophy they start readjusting their way of living and thinking to the organic way of life. This degree of adoption is envisaged from the way the farmers think organic farming has changed their lifestyle.

Table 9: Social Impacts of adoption of organic farming

Parameter	No Change	Positive	Negative	Can't Say
Impact on Health	51.23	48.75	0.00	0.02
Impact on Diet	69.91	23.57	0.00	17.52
Changes in Social Status	80.80	18.40	0.80	0.00
Changes in Social Image	80.06	16.93	0.00	3.01

SEP survey (2003)

We asked the adopters about their perception on how their health, diet, social status and social image have changed as a result of adoption of organic farming. The results reveal that almost half the adopters did perceive a positive health impact and a quarter perceived positive impacts on diet. Though significant number of respondents reported no change in social status and image to adoption decision, 17-18% of the respondents reported positive changes and almost no farmer reported any negative influence of adoption on any of these parameters. This indicates that atleast 17-18% of the farmers are moving closer to buying in the long-term sustainability philosophy of organic farming. Probably with time more and more farmers will buy in the philosophy, as they perceive the other intangible benefits of organic farming.

Table 10: Data on 'Soft' Variables

Parameter	Adopter Farmers	Non-Adopter Farmers
Soil has Become Softer	61.33 %	30.57 %
Soil can be Ploughed Easily	62.00 %	33.05 %
Increase in Soil Productivity	52.66 %	30.57 %
Reduced Water Requirement	21.80 %	5.00 %
Satisfaction with Work	85.60 %	65.90 %
Vision: Successful Farmer with more Irrigated Area	87.00 %	73.20 %

SEP survey (2003)

On some of the 'soft' (qualitative) variables, we asked the adopter farmers about their impressions, thinking and perceptions. The following results showed:

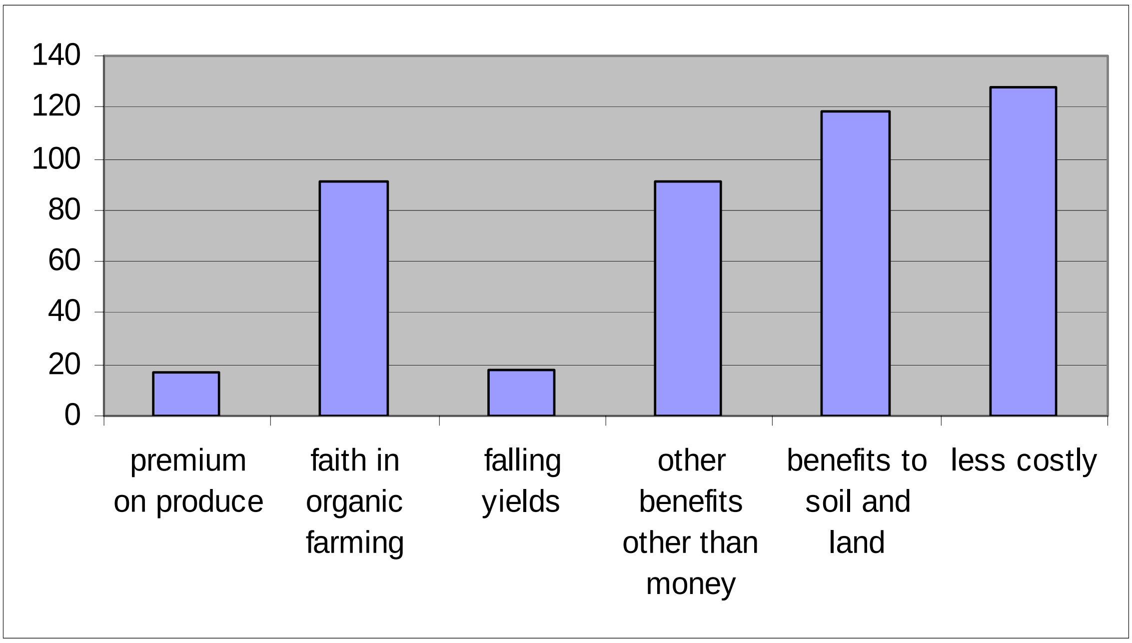
- A little over 60% of the adopter households reported softer and easier to plough soils and over 50% reported an increase in the productivity of soil as benefits of adoption;
- Roughly, one-fifth of the adopter households reported reduced water requirement for crops indicating to better soil moisture retention capacities of their farms;
- Overall satisfaction with their work was reported to be much higher among the adopter households compared to the non-adopter households;
- Finally, a large majority of the adopter households envisioned themselves as successful farmers with greater irrigated area over the next ten years while this proportion was much lower for the non-adopter households.

IV.3 Reasons for and Barriers to Adoption

Stated reasons for adoption of Organic farming

From a list of pre-defined options (which were generated through preliminary fieldwork and questionnaire pre-testing), we asked the adopter farmers to select all those which contributed to their decision of adopting organic farming. The results are presented in this section.

Figure 7: Stated Reasons for adoption of Organic Farming (number of responses)



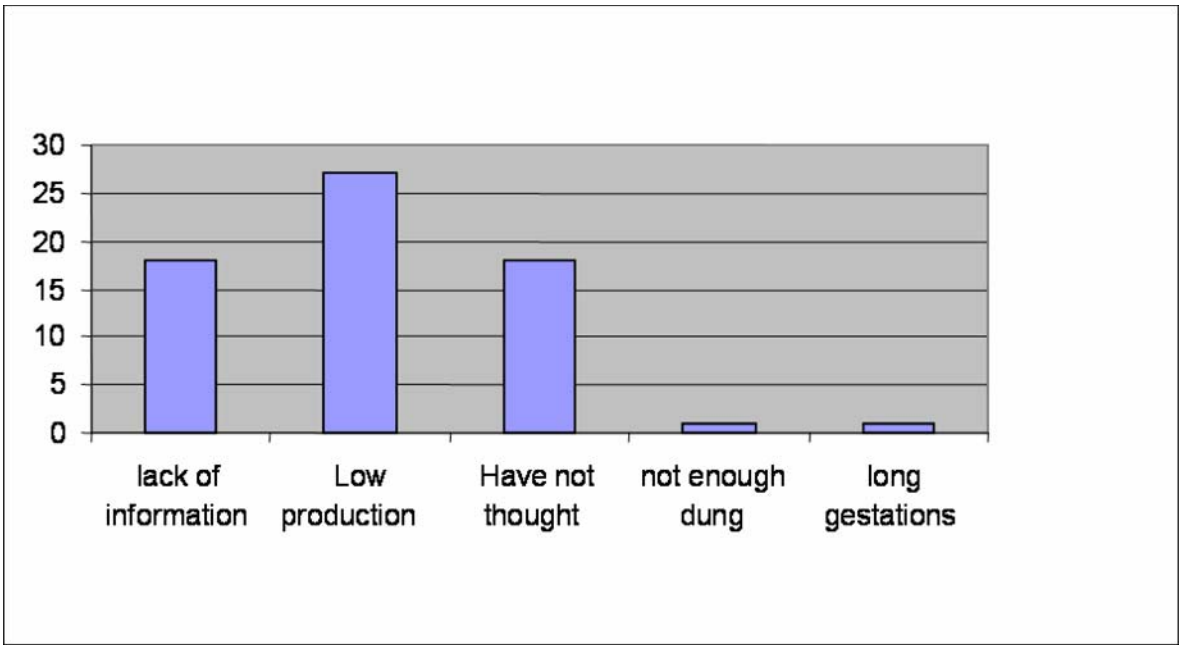
SEP survey (2003)

As seen from Figure 7, the largest stated reason for adoption of Organic Farming is the low input cost. Thus, a number of farmers were motivated to join organic farming due to the fact that they either could not afford high-input chemical farming or found the net returns from organic agriculture to be more remunerative. A large number of farmers also reported positive impact on their soil and land quality to be an important reason for adoption. Non-monetary benefits and faith in organic farming were also reported as reasons by around 90 farmers. This indicates that farmers are moving closer to buying in the long-term sustainability philosophy of organic farming. One significant finding in this analysis is that the premium is not ranked high by the farmers (though one must realize that even if this were an important factor in the decision matrix, most people would not like to state it as a primary reason for adoption while being interviewed by an outsider).

Prime Hindrances to Adoption

Again, from a set of pre-defined options, we asked the farmers about the prime hindrances to the adoption of organic agriculture. The following results were obtained.

Figure 8: Stated Hindrances for Adoption of Organic Farming (Number of responses)



SEP survey (2003)

The major hindrance for adoption of organic farming is the low yields which is associated with the shift from chemical farming to organic farming in for the initial three years. We also found farmers who said that they did not have enough information to make the decision to shift or have not given considerable thought to the issue. Though this is quite understandable because our sample included some villages where bioRe is not currently operating, it underlines the importance, scope and the need for further dissemination and extension work on the concept of organic farming in the region.

SECTION V: MICRO-IRRIGATION

In this section, we look at: [1] the profile of the adopters and non-adopters; [2] comparison of results from experimental plots and farmer field measurements; [3] economic and social impacts of adoption of micro-irrigation; and [4] reasons for and barriers to adoption.

V.1 Profile of Adopters and Non-Adopters

Table 11: Profile of adopters and non-adopters of micro-irrigation technologies

[a] LAND HOLDING

Parameter	Adopters	Non-Adopters	F-Statistic	Sig.	Sample Size		
					Adopters	Non-Adopters	Total
Avg. Land Holding	17.60	10.56	15.91	0.00	48	118	166
Avg. Gross Cropped Area in a Year	13.18	11.06	1.80	0.18	48	118	166
Cropping Intensity	1.35	1.40	5.40	0.46	48	118	166

[b] INDEBTEDNESS

Parameter	Adopters	Non-Adopters	F-Statistic	Sig.	Sample Size		
					Adopters	Non Adopters	Total
Avg. Value of Debt (past 3 yrs.)	20534.10	11334.66	3.92	0.04	66	145	211
Avg. Value of Debt per Acre	11332.42	3631.98	12.02	0.01	66	145	211

[c] CENTRALITY OF COTTON

Parameter	Adopters	Non-Adopters	F-Statistic	Sig.	Sample Size		
					Adopters	Non Adopters	Total
Land under Cotton per Household	7.29	5.08	10.023	0.00	48	118	166
Proportion of Land under Cotton	0.60	0.60	0.00	0.99	48	118	166

[d] LABOR AVAILABILITY

Parameter	Adopters	Non-Adopters	F-Statistic	Sig.	Sample Size		
					Adopters	Non Adopters	Total
Land-Man Ratio	4.03	3.19	4.4	0.03	86	111	197
Avg. Annual Expenditure on Hired Labor per Acre	1146.00	928.88	0.65	0.42	53	129	182
Labour Man-Days in the field	1041.80	1098.03	0.49	0.48	124	166	290

[e] WATER CONTROL

Parameter	Adopters	Non-Adopters	F-Statistic	Sig.	Sample Size		
					Adopters	Non Adopters	Total
Well Density per 100 Acres	10.45	11.31	0.34	0.56	77	105	182
Tube-well density per 100 Acres	3.39	1.86	4.15	0.04	76	105	181
Number of months in a year when water is available in well/tube-well	5.95	8.40	24.09	0.00	172	157	329

SEP survey (2003)

[f] ECONOMIC WELL-BEING

Parameter	Adopter Farmers	Non-Adopter Farmers
Kitchen Expenses (> Rs. 1000 p.m.)	80.50 %	50.40 %
Household Expenses (> Rs. 1000 p.m.)	81.90 %	46.60 %
Education Expenses (> Rs. 500 p.m.)	45.80 %	27.20 %
Incidence of Migration	0.60 %	1.32 %
Outstanding Debt Liabilities	74.80 %	60.80 %
Satisfaction with Work	73.70 %	46.00 %

SEP survey (2003)

Table 11 provides an overview of the Micro-tube adopters and non-adopter profiles. Based on the data above, we summarize some important points:

- Our initial hypothesis was that farmers having large landholdings would opt for micro irrigation, since drip farming is a high-investment system of farming. This was proved to be correct. The average drip adopters own more land; but though they have higher gross cropped area and greater cropping intensity, the differences among means were not found to be significant.

- Our initial hypothesis was that farmers having greater access to credit would opt for drip technology. This was found to be true by higher values of average debt across three years for drip adopter farmers and the showing significant differences in debt per acre values between adopters and non-adopters. This difference would have come out to be even greater if bioRe would not have offered drips to some of its member farmers under a zero-interest and easy installment scheme.

- That more land is brought under cotton cultivation is seen from the fact that the proportion of land under cotton is slightly higher for drip adopters. Our results from the *Pepsee* survey (which was based on a before-after recall survey) also show that on an average, drip adopters are able to bring ~2.20 acres of additional land under irrigation (Verma, Tsephal and Tony 2004). However in the case of SEP survey we are comparing land area under cotton between adopters and non-adopters of drip irrigation.

- One of the main reasons for the farmers adopting drip irrigation is scarcity of water. Though drip farmers show higher tube-well density, the well density and the availability of water throughout the year is lower than that of non-adopters.

The higher tube-well density could be because the large farmers who adopt drip farming can make large investment in digging tube-wells.

- Some of the parameters on economic well-being show similar trends between adopters and non-adopters of water saving technologies. In fact, the differences between the adopters and non-adopters are even more prominent in this case (compared to differences between organic and chemical farmers) except that the adopters have a higher incidence of outstanding debt liability. This might be due to the additional investments required for adoption and the absence of an agency to promote and support adoption, as in the case of organic adoption.

Thus, typically, drip adopters are farmers who have greater land but less access to water. These are the ones who are probably worst hit by the falling water tables in the region and in an effort to maintain their irrigated area, have taken to drip irrigation.

V.2 Experimental Plots and Farmer Field Measurements

RESULTS FROM EXPERIMENTAL PLOTS

Table 12: Comparison Across Micro-Irrigated Pre-monsoon plots and Furrow Irrigated Monsoon plots in the experimental plots

Parameter	Micro-Irrigated Pre-monsoon plots	Furrow Irrigated Monsoon plots
Land Productivity (Quintals/Acre)	3.40	2.31
Water Productivity (Kgs/Cubic Metre)	0.61	0.48
Irrigation Water Applied (Litres)	175.69	152.48
No of Pre-Monsoon Watering	15	0
No of Post-Monsoon Watering	5	5

- From the results of the Experimental plots we can infer that the yields from plots which are sown in the pre-monsoon (3.40 Quintals/Acre) and which also use micro-irrigation show a 47.35% increase in yields as compared to furrow irrigated monsoon plots (2.31 Quintals/Acre).
- The water productivity for pre-monsoon, micro-irrigated plots (0.61 Kgs/Cubic Metre) was 27.27% higher than furrow irrigated monsoon plots (0.48 Kgs/Cubic Metre).

Figure 9: Land Productivity across types of irrigations

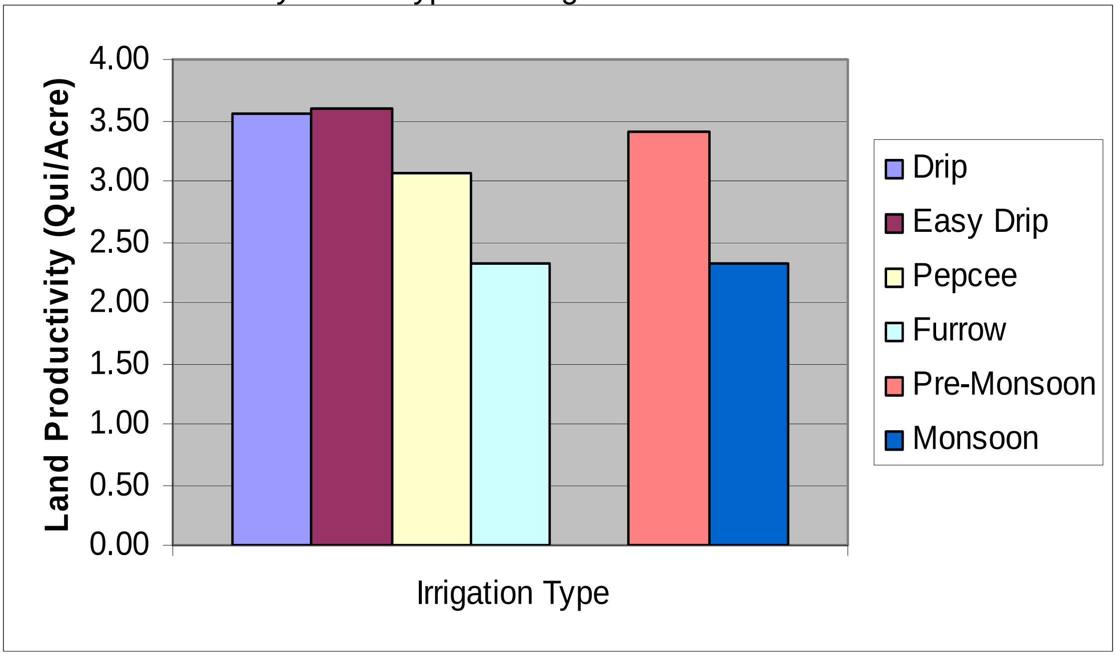
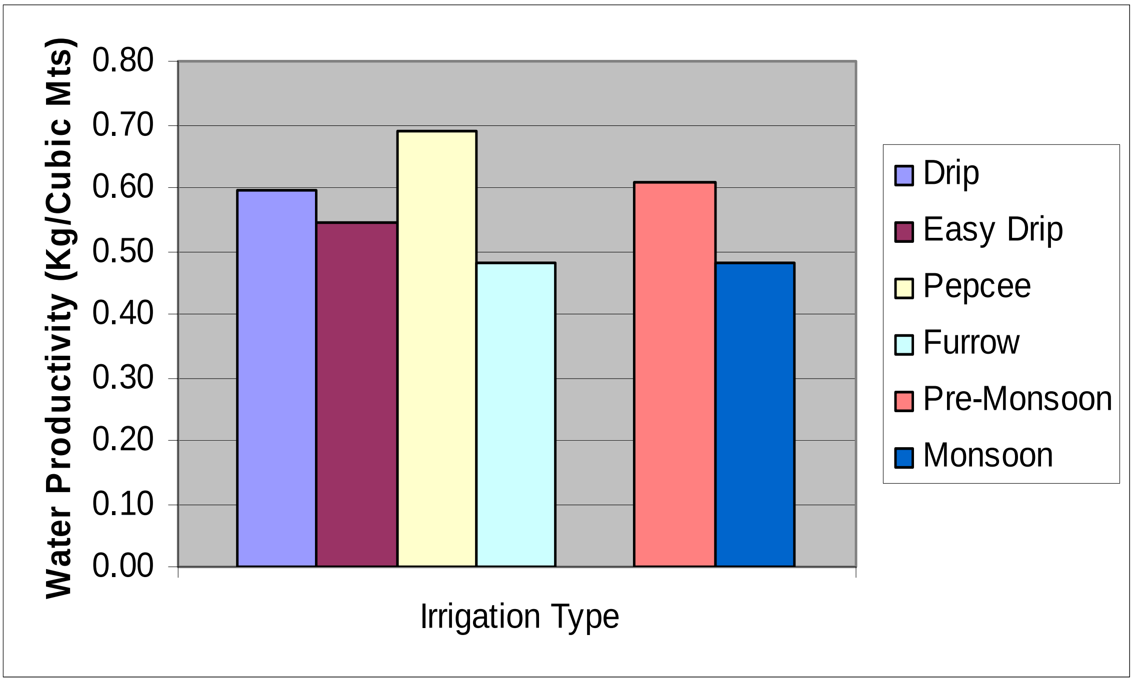


Figure 10: Water Productivity across types of irrigations



- There is a steady increase in the land productivity and water productivity as we move from lower water saving technologies like narrow furrow to higher water saving technologies like conventional drip. Also the land productivity and water productivity for pre-monsoon cotton is higher than monsoon cotton.
- It is also worth noticing that the total water supplied for irrigation for pre-monsoon, micro-irrigated plots (175.69 litres) was 15.22% more than that of furrow irrigated monsoon plots (152.48 litres). This is because even though there is a saving in the water applied per plant per day in micro-irrigation, the number of irrigations in

case of pre-monsoon cotton (20 irrigations), which includes 15 pre-monsoon watering, is much more than that of monsoon cotton (5 irrigations).

The factors which differ between the experimental plots and farmer fields are:

- Cropping Pattern
- Water Application
- Irrigation Pattern
- Plant Density
- Plant Duration
- Number of watering
- Soil Type
- Seed Varieties
- Trend in Prices of Cotton

RESULTS OF FARMER FIELD MEASUREMENTS

Table 13: Water Application across different cotton cropping patterns in farmer fields

Type of Farming	Type of Irrigation	Max irrigation water applied (lit/plant/day)	Min irrigation water applied (lit/plant/day)	Avg irrigation water applied (lit/plant/day)
Pre-monsoon irrigation for Pre-Monsoon Cotton	Drip irrigation	3.72	1.52	2.30
	Furrow irrigation	3.34	2.87	3.11
Post-Monsoon irrigation for Pre-monsoon cotton	Drip farmers with furrow irrigation	9.39	2.26	3.48
	Furrow irrigation	5.00	2.26	6.51
Post Monsoon irrigation for Monsoon cotton	Furrow irrigation	9.39	2.31	4.12

The water applied per plant in the pre monsoon season for farmers using Drip irrigation varies over a range for 1.52 lit/plant/day to 3.72 lit/plant/day and the average is 2.3 lit/plant/day. While the water applied per plant in the pre monsoon season for farmers using Furrow irrigation varies over a range of 2.87 lit/plant/day to 3.34 lit/plant/day and the average is 3.11 lit/plant/day, which is 35% more water applied than their drip counterparts for pre-monsoon irrigation. The water applied per plant for pre-monsoon farmers is higher than the water applied per plant of 1.79 lit/plant/day for the experimental plots.

The post monsoon data of pre-monsoon, drip farmers varies from 9.39 lit/day/plant to 2.26 lit/day/plant with an average of 3.48 lit/day/plant. Compared to this the post-monsoon data for furrow pre-monsoon, furrow farmers varies from 5 lit/plant/day to 2.26 lit/plant/day with an average of 6.51 lit/plant/day.

While the farmers who plant cotton in monsoon has water application rates varying from 9.39 lit/day/plant to 2.31 lit/day/plant and an average of 4.12 lit/day/plant.

IRRIGATION PATTERN

Farmers noticed that the discharge from the tubewells would taper off with time as irrigation progressed during a single irrigation itself. However this problem was solved by the farmers, in this region, who had poor tubewell yields by drawing water from the tubewells and storing it in the wells. This water in the wells is then utilized for irrigation by pumping through smaller capacity pumps from the well to the fields. The water applied by each farmer differs due to the depth of the well and distance of the well from the field.

Figure 11: Irrigation Pattern for Pre-Monsoon Drip Cotton during summer

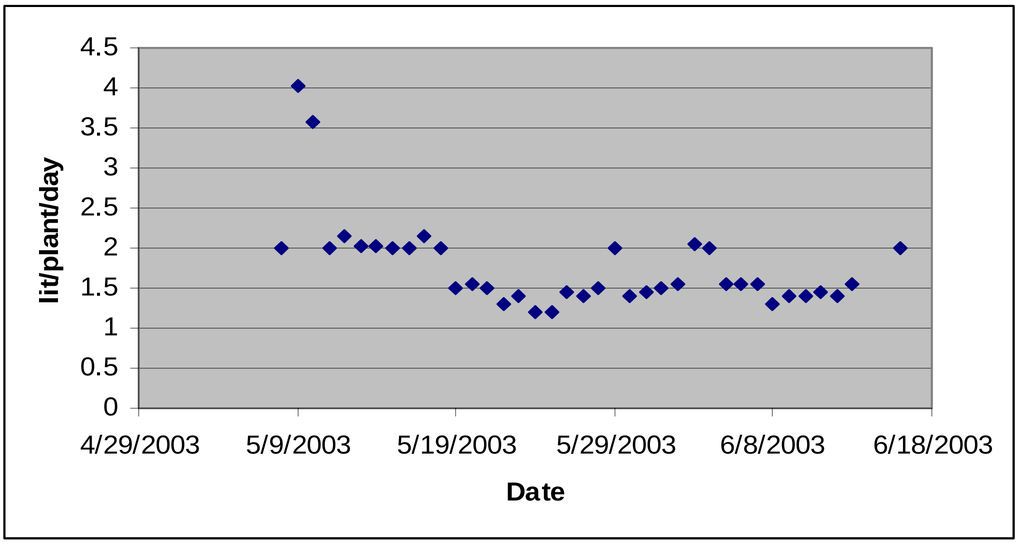
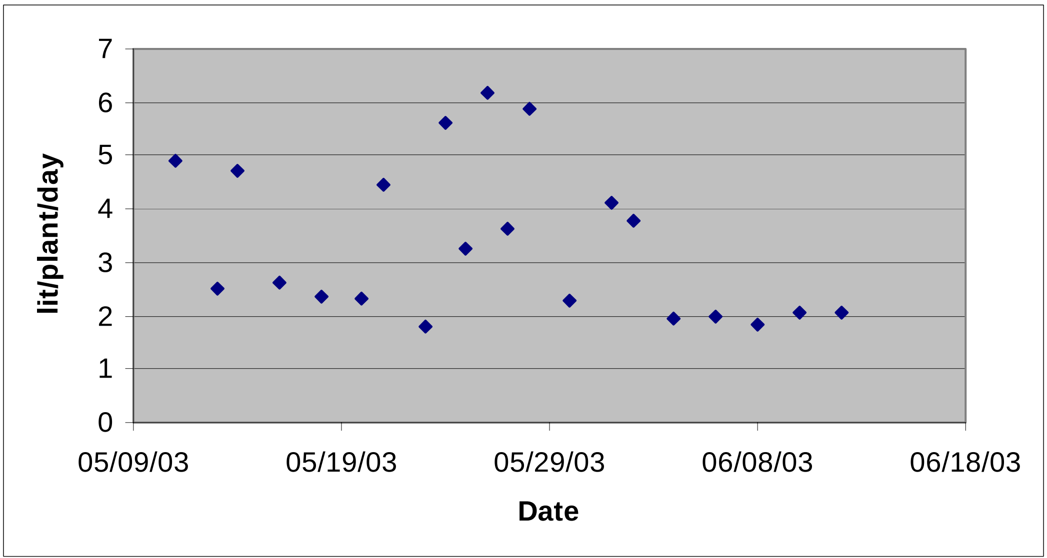
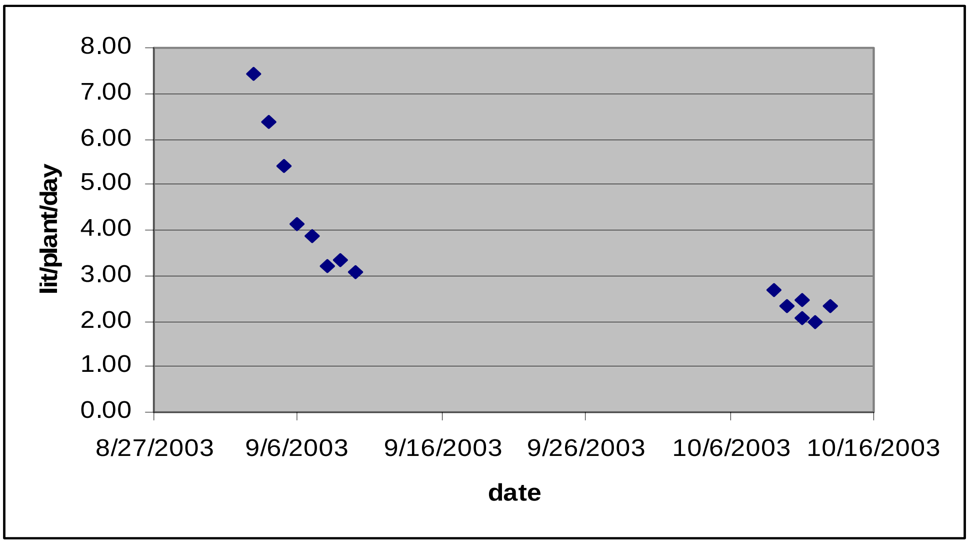


Figure 12: Irrigation Pattern for Pre-Monsoon Furrow Cotton during summer



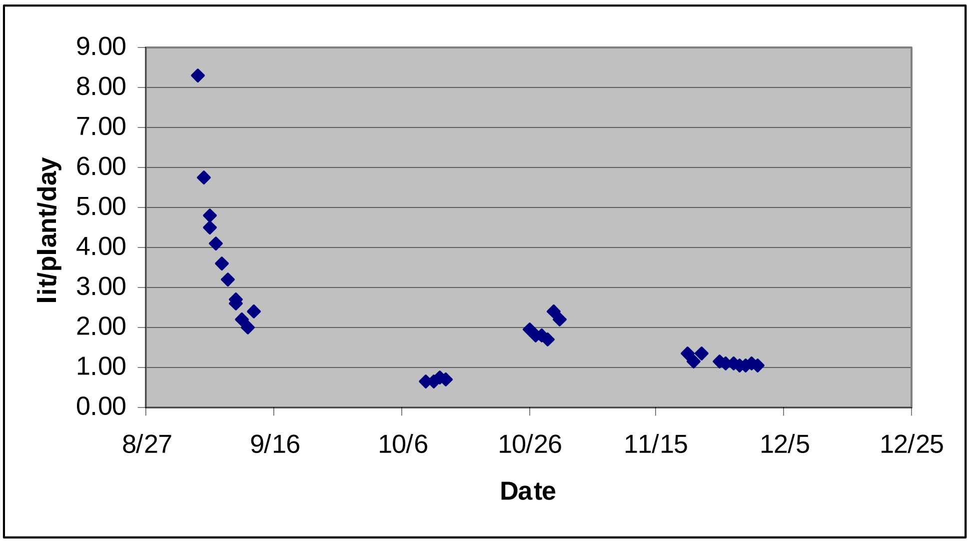
- Figure 9 shows the water application in lit/plant/day for pre-monsoon drip irrigation and figure 10 shows the water application in lit/plant/day for pre-monsoon furrow irrigation for the same farmer. From the graphs we can infer that the water application through drip irrigation is far more uniform than furrow irrigation. This is because the farmer has more control on the water being transferred to his fields in case of drip irrigation while in case of furrows he will apply water depending on the power availability and also water available to him in the well. Depending on the water availability, the watering is done on everyday or on alternate days before the first rains.

Figure 13: Irrigation Pattern for Pre-Monsoon Cotton who takes wheat in winter



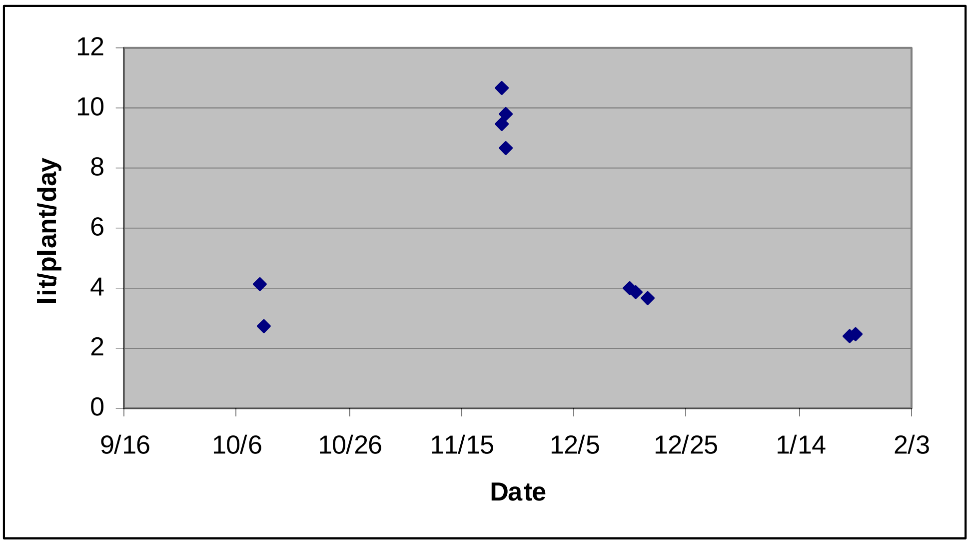
- In case of the farmer who does pre-monsoon cotton and wheat in rabi on the same land, the post-monsoon irrigation pattern is shown in figure 11. The farmer does his first watering immediately after the rains and limits himself to only two watering before harvesting the cotton crop at the end of first flush. After which he goes for the sowing of the wheat crop.

Figure 14: Irrigation Pattern for Pre-Monsoon Cotton who takes cotton for the second flush



- In case of the farmer who does pre-monsoon cotton and harvests it up to the end of second flush, as seen in figure 12, there is a large irrigation after the end of the monsoon season in October, coinciding with the start of the second flush. The farmer usually does 4-5 watering depending upon the water availability.

Figure 15: Irrigation Pattern for Monsoon Cotton who takes cotton for the second flush



- In case of the farmer who does monsoon cotton (figure 13), we find that a large amount of water is applied at the end of the first flush in November and beginning of the second flush, which usually coincides with the second post-monsoon irrigation. The farmer usually gives 4-5 irrigation depending upon the water availability.
- In all the irrigation patterns we find that the farmers usually apply more water for the first irrigation after the end of the monsoon season and also for the start of the second flush. This is also the time when the wells are usually full of water. The application of water decreases in the subsequent waterings and also the spacing of the irrigations are very uneven, which can have an effect on the yield of cotton.
- We see that not only is there a large variation in the post monsoon water application rates of farmers across all the categories but there is also a large difference between the water application done by drip method and by furrow method. This huge variation can be understood by looking at the irrigation pattern of the farmers adopting the different cotton cropping patterns. Within each cropping pattern there is difference in the plant duration which has further implications on the number of watering and thus the water application.
- Though drip irrigation is used only for irrigation in pre-monsoon cotton to bring more land area under cotton, it can be certainly used to provide the first irrigation for the second flush of cotton. Drip irrigation can not only help the farmers not to over-irrigate their lands just after the rains when there is lot of water in the wells, but will also space their irrigations effectively which can help them increase their yields in the second flush.

<u>SEED VARIETIES</u>

All the farmers in the study have used hybrid seeds which are easily available in the local market. But since there is no guarantees on the quality of the seeds, most of the farmers try different varieties of seed on the same plot to ascertain which variety of seed is best suited for his plot. The most common variety of seed used by the farmers is H8, JKH1, Ajit-11 etc. A couple of farmers in our sample have also adopted BT seeds.

For the purpose of analysis we have divided the seeds into high yielding, medium yielding and low yielding seeds. The BT seeds are higher yielding seeds which can give yields as high as 8-12 quintals per acre and the other hybrid seeds are medium yielding seeds with yields ranging from 4-8 quintals per acre. The other local varieties have yields between 2-4 quintals per acre.

PLANT DENSITY

Table 14: Variation in Plant Density

Type of farming	Max plant density	Min plant density	Average plant density	Standard Deviation
Drip irrigation	4864	3347	3775	568
Furrow irrigation	5397	2720	3945	1001

The average plant density for the experimental plots is 3238 plants per acre, which is achieved by providing standard 3*3 feet spacing between the plants. But when we see the farmer fields there are large variations in the plant density across farmers. It varies from 4864 plants per acre to 2785 plants per acre for pre-monsoon cotton and 5397 plants per acre to 2720 plants per acre for monsoon cotton. The average plant density is 3681 plants per acre for pre-monsoon cotton and 4126 plants per acre for monsoon cotton.

The high variability in the plant density in monsoon is because farmers use different plant spacing depending on the type of soil in his farm and the variety of seed used. The usual spacing for cotton crop is 3*3 feet. But there are farmers who also adopt a spacing of 3*4 if he has a heavy soil type in his farm. A farmer having lighter soil in his farm will usually adopts a smaller spacing of 2*2 feet which increases the plant density and farmers who do not have irrigation resources spray the seeds on the field and leave it to germinate. The rate of germination of seeds also has an effect on the plant density. Lower germinating seeds reduce the plant density and vice-versa.

Table 15: Relation between Plant Duration, Number of Watering and Water Application

	Date of Sowing	Date of Harvesting	Plant Duration (Days)	No of pre-monsoon waterings	No of post monsoon waterings	Water Application (lit/plant)
Experimental Plots Pre monsoon	15/5/2003	2/3/2004	288	15	5	175.69
Experimental Plots Monsoon	21/6/2003	2/3/2004	251	0	5	152.48
Drip Pre-monsoon	9/5/2003	19/2/2004	280	41	4	553.72
Drip Pre-monsoon	17/5/2003	1/3/2004	284	33	4	282.96
Drip Pre-monsoon	14/5/2003	29/2/2004	286	24	2	280.42
Drip Pre-monsoon	8/5/2003	18/3/2004	310	39	4	346.44
Drip Pre-monsoon	8/5/2003	17/3/2004	309	39	4	534.29
Drip Pre-monsoon	7/5/2003	26/10/2003	169	38	2	481.36
Furrow pre-monsoon	8/5/2003	1/11/2003	173	21	2	215.47
Furrow pre-monsoon	11/5/2003	26/10/2003	165	21	2	537.94
Furrow monsoon	19/6/2003	8/3/2004	259	0	6	237.51
Furrow monsoon	21/6/2003	3/2/2004	222	0	4	277.2
Furrow monsoon	14/6/2003	5/4/2004	291	0	3	253.76

Furrow monsoon	24/6/2003	15/3/2004	261	0	4	640.68
Furrow monsoon	20/6/2003	1/3/2004	251	0	4	157.45
Furrow monsoon	22/6/2003	1/11/2003	129	0	2	140.85

- Plant Duration varies from 310 days to 165 days for Pre-monsoon cotton farmers and varies from 291 to 129 days for monsoon cotton farmers.
- The number of watering for pre-monsoon cotton varies from 45 to 23 and for a monsoon farmer varies from 6 to 2.
- The total water applied per plant varies from 553.32 lit/plant to 215.47 lit/plant for pre-monsoon farmers and for monsoon farmer varies from 640.68 lit/plant to 140.85 lit/plant.
- The total water applied per plant is not affected by the plant duration, but the number of waterings and the amount of water applied per watering does have significant effect on it. The cotton farmers usually over-irrigate at the end of the first flush, when there is more water in their wells after the rains.

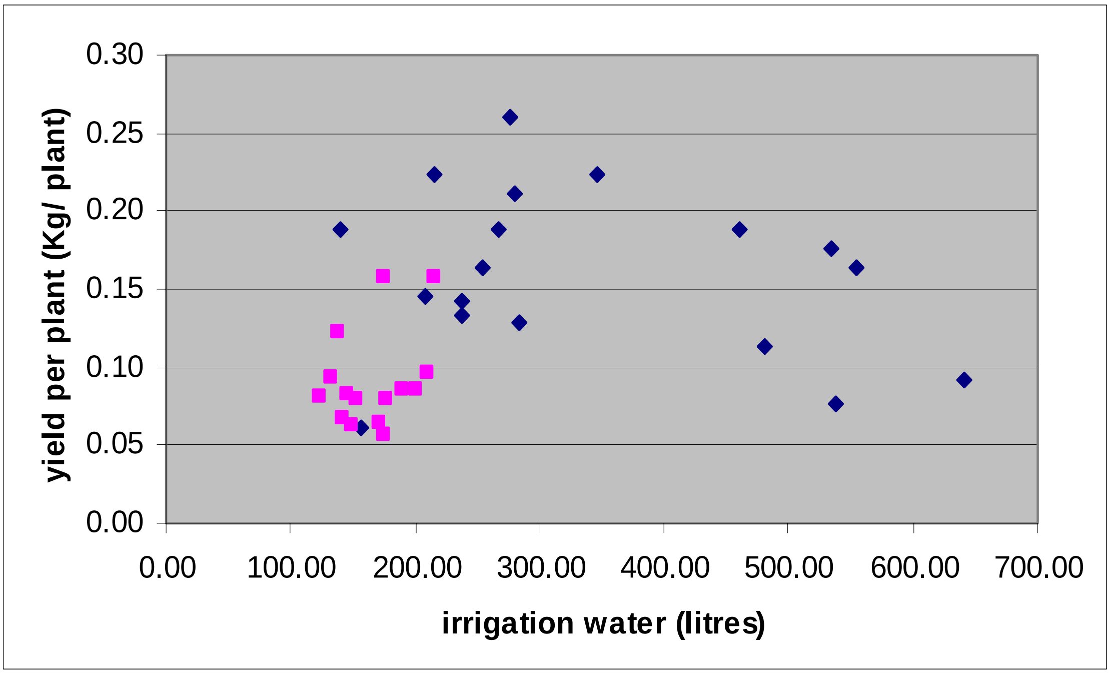
Table 16: Relation between Soil Type, Plant Duration, Water Application and Yield

	Soil Type	Plant Duration (Days)	Water Application (Lit/Day)	Yield per Acre (Qui/Acre)
Pre monsoon Plots	Light	288	175.69	3.40
Monsoon Plots	Light	251	152.48	2.31
Drip Pre-monsoon	Heavy	280	553.72	6.12
Drip Pre-monsoon	Heavy	284	282.96	6.25
Drip Pre-monsoon	Heavy	286	280.42	8.12
Drip Pre-monsoon	Heavy	310	346.44	7.61
Drip Pre-monsoon	Heavy	309	534.29	6.08
Drip Pre-monsoon	Light	169	481.36	3.80
Furrow pre-monsoon	Heavy	173	215.47	6.21
Furrow pre-monsoon	Light	165	537.94	3.07
Furrow monsoon	Heavy	259	237.51	7.58
Furrow monsoon	Heavy	222	277.2	8.21
Furrow monsoon	Heavy	291	253.76	8.25
Furrow monsoon	Light	261	640.68	3.98
Furrow monsoon	Light	251	157.45	3.75
Furrow monsoon	Heavy	129	140.85	5.13

- Application of more water per plant does not necessarily lead to higher yields. But other factors like pest attack, rainfall pattern, soil type also effect yields.
- Farmers having lighter soil type apply more water per plant for both drip farmers as well as furrow farmers as compared to farmers having heavy soil.. Also the distributive efficiency of irrigation in case of lighter soils is less than that of heavy soils, so more water is applied per plant. Farmers with lighter soil keep closer plant spacing. This helps them to get higher land productivity. This also makes them apply more inputs like fertilizers to increase their yield from a small patch of land.
- The main objective of the farmer in Maikaal is to increase net returns from farming, which he does by trying to increase the production of cotton, under the constraints of credit availability, water and power availability, soil type, climatic factors and market factors. Thus he achieves his objective by using better seeds,

higher inputs, changing cropping pattern etc depending upon the various constraints. For every constraint the farmer tries to use a certain farming practice which will optimize his yield, given all the other conditions remain same.

Figure 16: Optimum Water Application per Plant for Cotton



- Higher water application does not necessarily result in higher yields. In the experimental plots it was between 150 lit/plant to 250 lit/plant, whereas it was varying from150 lit/plant to 650 lit/plant in farmer fields. There is a threshold level of water application for a cotton plant is between 200-300 lit/plant, beyond which any more water application does not increase yield substantially.
- Thus we find that drip technology is used only in pre-monsoon cotton irrigation pattern in West Nimar to take maximum benefits from the available water in the wells, by increasing land area under cotton. Also drip farmers are able to utilize their water more efficiently, when water is scarce during the summer months as compared to conventional farmers.

V.3 Economic and Social Impacts of Adoption

The results presented in this section are based on recall data collected from the farmers. It must be emphasized here that there might be overlaps between these impacts and adopter profiles. Since the data is collected using a 'with-without' sampling procedure, some of these 'impacts' might also reflect characteristics of adopter households. For example, we find that drip adopters have higher monthly kitchen expenses. This need not necessarily mean that the higher expenses can be attributed only to the adoption decision. It might be that the adopters (who we have seen above are large farmers) already had higher monthly kitchen expenses, even before adoption. The same care needs to be taken while interpreting results on other parameters for drip as well as organic adopters.

ECONOMIC IMPACTS

Adoption of micro-irrigation (among other benefits) facilitates pre-monsoon sowing of cotton. The potential benefits of this have already been discussed in section IV.2 above. In addition, adoption of these technologies means an increase of 2-3 acres (on an average) in the irrigated area of the adopter. Like we had done for the crop economics comparison between organic and chemical farmers, we used a smaller (more reliable) sample of 170 farmers.

Table 17: Crop Economics for Drip and Conventional Farmers

Parameters	Drip Farmers	Conventional Farmers
Sample Size	58	112
Average Cotton Land (Acres)	6.69	4.78
Average Seed Cost (Rs/Acre)	525.23	620.49
Average Fertilizer Cost (Rs/Acre)	601.20	613.64
Average FYM Cost (Rs/Acre)	1970.83	1811.23
Average Pesticide Cost (Rs/Acre)	230.70	202.90
Average Labour Cost (Rs/Acre)	565.73	903.82
Average (Total) Production Cost (Rs/Acre)	3893.69	4152.08
Average Yield per Acre (Quintals/Acre)	3.85	4.25
Average Price (Rs/Quintal)	2764.55	2569.51
Average Net Profit (Rs/Acre)	8678.78	7141.94

SEP survey (2003)

From the crop economics table we can further conclude that:

- The drip farmers have more cotton land than conventional farmers. This is perhaps because they are able to bring more land under irrigation with the use of drip irrigation.

- Drip farmers also have lower labor costs and their overall production costs are also (slightly) lower. This is because the use of drip irrigation reduces the need for weeding and labour costs associated with operation of irrigation pumps.

- In our sample, drip farmers have lower yields. This is because in the survey year, the rainfall pattern was such that the yields of the pre-monsoon sowers went down. Inspite of this, the drip farmers have, on an average, more than 20% higher net profit per acre. This additional profit can largely be attributed to the better price they are able to command in the market by virtue of the timing of their harvest.

- If we take into account the fact that adoption of drip will, on an average bring an additional 2.2 acres of land under irrigation (Verma, Tsephal and Jose 2004; see below), the total benefits from adoption of drip irrigation will get multiplied.

Table 17: Difference in pumping between *Pepsee* adopters and flood/furrow irrigators (Verma, Tsephal and Jose 2004)

Method of Irrigation	Average Number of Irrigations	Average Hours of Irrigation/Acre	Total Hours of Pumping/Acre
Pepsee	18	0.42 Hrs	7.50 Hrs
Flood/Furrow	3	5.00 Hrs	15.00 Hrs

Table 18: Impacts of adoption of drip irrigation on agriculture (SEP Survey)

Parameters	Adopters	Non-Adopters
Pre-ponement of sowing date	21 days	-
Increase in Area under Irrigation	2 to 3 acres	-

SEP survey (2003)

- Table 17 shows the differences in the pumping behavior of Pepsee adopters and flood/furrow irrigators. The total hours of pumping per acre is halved as a result of adoption. However, this does not mean that the total pumping hours of a pump are reduced. The 'saved' pumping hours are used to bring additional area under irrigation.

- As we can see from table 18, drip farmers are able to prepone their sowing date, on an average, by 21 days. The data from the Sep survey also confirms the results of the *Pepsee* study, indicating a 2-3 acres increase in area under irrigation.

- Another important aspect of micro-irrigation adoption is the change in frequency of irrigation. The requirements under drip irrigation seem to be well-suited to the power supply regime and the groundwater conditions in the region. Instead of needing a continuous power supply of 5 hours thrice (as is the case in flood/furrow irrigation), drip adopters need to irrigate more frequently but for shorter time periods. This matches power supply and is also suitable for those farmers whose wells run dry within an hour of pumping and recover slowly.

Box 1: Stated Advantages and Disadvantages of *Pepsee* Systems

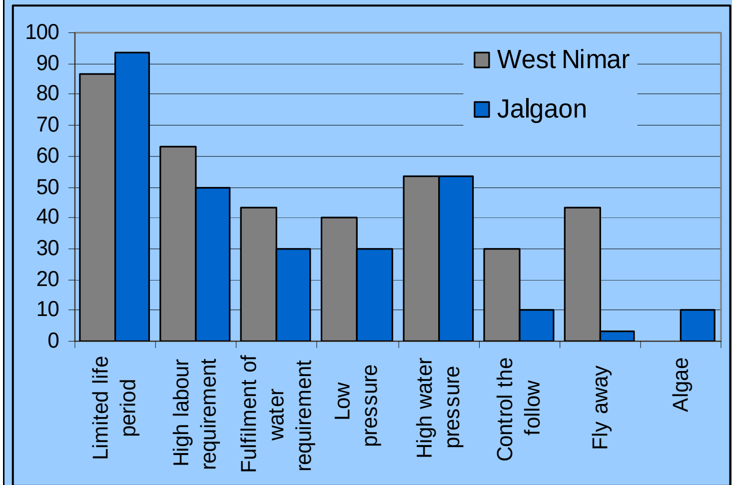


Figure 17: Perceived Disadvantages of *Pepsee* Systems in Jalgaon and West Nimar.

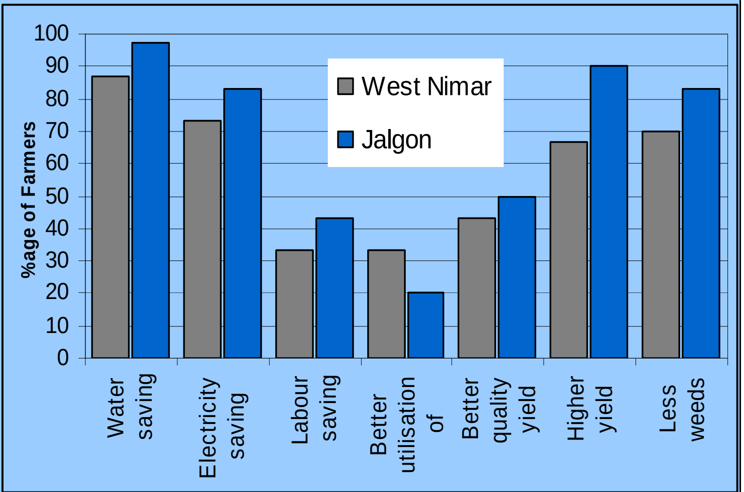


Figure 18: Perceived Advantages of *Pepsee* Systems in Jalgaon and West Nimar.

Figure 15 illustrates some of the advantages of *Pepsee* as stated by cotton farmers in West Nimar and Jalgaon. Though the benefits are largely the same, there are differences in relative importance which the farmers attribute to the different benefits. This difference in perception across the two areas for same technology is primarily because of early penetration of matching technologies like micro-tubes and drips in Maharashtra (Jalgaon). In West Nimar, technologies like micro-tubes and drip systems are relatively new and the numbers of adopters is also less. Most farmers of West Nimar look at micro irrigation technologies only as a coping mechanism to groundwater stress. In Jalgaon, however, precision irrigation technologies have been popular for more than two decades and the farmers perceive other benefits such as higher yields, labour saving, etc as well.

Even with all the advantages listed above, *Pepsee* systems are not without problems. One of the major problems encountered under *Pepsee* is the clogging of the holes of the plastic straw. This clogging is not caused by sand and other small particles, as in case of micro-tubes and drips, but by organic matter, bacterial slime, algae and/or chemical precipitates. The *Pepsee* straw can be used only for one year, in certain cases for two years (depending upon the number of microns). Since the *Pepsee* straw is very thin (and is not UV-stabilized), after a few months, it gets burnt out easily due to the scorching sun; also, high pressure of water can tear off the straw. One of the other major problems faced by the farmers of West Nimar, is that strong winds in the region blow away the *Pepsee* straw. However, farmers in West Nimar are overcoming this weakness of the system through various innovations like covering the straw with bricks, and other local innovations. Other technical disadvantages of *Pepsee* include uneven distribution of water, the problem of low pressure at tail end and high pressure at the head. Due to high pressure at the head, the holes become bigger and more water flows out.

Figure 16 illustrates some of the disadvantages of *Pepsee* as stated by the farmers in West Nimar and Jalgaon. 85-95% percent farmers believe that the limited life period of *Pepsee* is its biggest disadvantage. The high labour requirement and that *Pepsee* cannot fulfil the water requirements of plants after a given stage are not actual disadvantages but differences in perception. In West Nimar, none of the farmers attempted to use *Pepsee* after the kharif season because of two reasons: first, there is sufficient water available in the wells and second, they feel that the application of water drop-by-drop can fulfil the crop requirements only when the plant is small. High labour requirement is generally perceived by new adopters as the introduction of new technology unsettles their old system and routine of work. As the numbers of years of usage increases, they get accustomed to the new system and start perceiving more of the benefits and find innovative solutions to overcome the drawbacks. This largely explains the differences between the perceptions in the two regions.

B. Social Impacts

Table 20: Social Impacts of adoption of water saving technologies

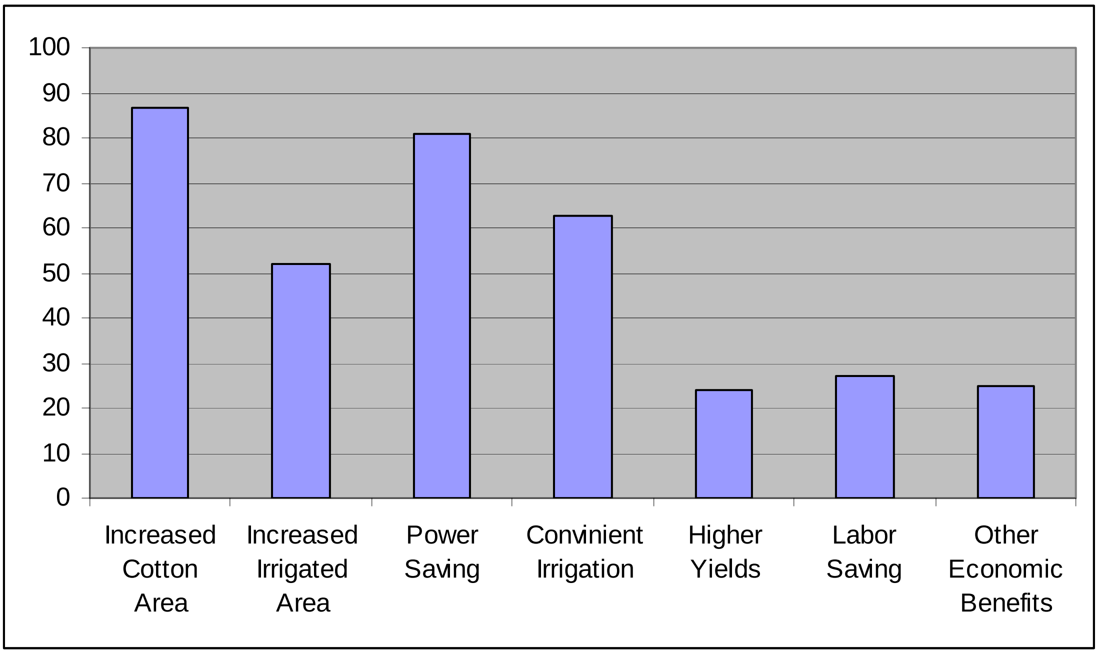
Parameter	No Change	Positive	Negative	Can't Say
Impact on Food Availability	100.00	0.00	0.00	0.00
Impact on Diet	100.00	0.00	0.00	0.00
Changes in Social Status	93.75	6.25	0.00	0.00
Changes in Social Image	100.00	0.00	0.00	0.00

SEP survey (2003)

The social impacts of micro-irrigation adoption are not perceived to any significant effect.
The farmers do not perceive any changes (positive or negative) on food availability; even though we have seen that household kitchen expenses are higher. Only 6% of the interviewed farmers reported a positive impact on social status of the adopters. However, just as in the case of organic farming adopters, none of the farmers reported any negative impact whatsoever.

V.4 Reasons for and Barriers to Adoption

Figure 19: Stated Reasons for adoption of micro-irrigation (number of responses)



SEP survey (2003)

As is evident from Figure 17, the dominant reasons for adoption of water saving technologies are short-run. Farmers view the technologies as coping strategies against the declining cultivated and irrigated area caused by water scarcity and power shortages. Other benefits such as higher yields and labor saving are perceived by fewer adopters. Thus, the spread of micro-irrigation in Maikaal has followed a trend similar to the one seen in Jalgaon and Saurashtra. The primary reason for the uptake of drip technologies in Jalgaon was the labor and power shortages while in Saurashtra, drips are catching on primarily as a mechanism to cope with the salinity problem.

FACTORS INFLUENCING CHOICE BETWEEN DIFFERENT TECHNOLOGIES

Unlike in the case of organic adoption, the adoption of water-saving technologies offers a range of options for the farmers. A large number of different products and techniques are available for the farmer to choose from. In this section, we try to analyze the process of this choice within the group of adopters. Why do farmers (from among the adopter group) choose a particular product/technology vis-à-vis the others? Broadly, we categorize water saving technologies into four categories: [1] Narrow and Alternate Furrow Irrigation; [2] *Pepsee* and Easy Drip Systems; [3] IDE's Low-Cost Micro-Tube Systems; and [4] Conventional Drip Irrigation Systems. Table 21 below presents the costs involved in the adoption of the different technologies.

Table 21: Additional Costs per Acre for different Micro-irrigation Technologies

Technology → / **Parameters**	*Pepsee*/ Easy Drip	Micro-Tubes	Drip Systems	Non Adopters
Additional Cost per Acre of Cotton Cultivation (4*4 spacing)	Rs. 4000-5000	Rs. 7000-8000	Rs. 18000-20000	Only Labour Cost
Avg. Land Holding (Acres)	19.55	15.82		12.28

Avg. Gross cropped Area	22.27	19.27	14.45

Source: Verma, Tsephal and Jose (2004)

Table 22: Average Land Holdings for *Pepsee* and Micro-tube adopters in Jalgaon and Maikaal

Region →	**West Nimar**			**Jalgaon**		
Technologies →	*Pepsee* Adopters	Micro-Tube Adopters	Non Adopters	*Pepsee* Adopters	Micro-Tube Adopters	Non Adopters
Average Land Holding (Acres)	20.00	24.50	14.60	14.50	21.50	9.70

Source: Verma, Tsephal and Jose (2004)

As is evident from the Table 22, the small farmers adopt the less capital intensive technologies. This result is from our survey of 180 farmers in West Nimar and Jalgaon[10] which did not specifically include bioRe farmers in the sample. However, in the larger survey of 400 farmers in Maikaal (Table 21), which included member farmers of bioRe, we found that the average land holding for drip adopters was not very different from (and was in fact lower than that of Pepsee adopters). This could be due to the effective promotion of drips (micro-tubes) by bioRe to its farmers and the lucrative terms offered under the scheme, which prompted a number of small farmers to adopt drips. It must be noted here that the non-adopters in both the tables above include non-irrigators as well. These are basically small and marginal farmers who practice rain-fed farming.

Box 2: Reasons for Purchasing and Not-Purchasing *Pepsee*[11]

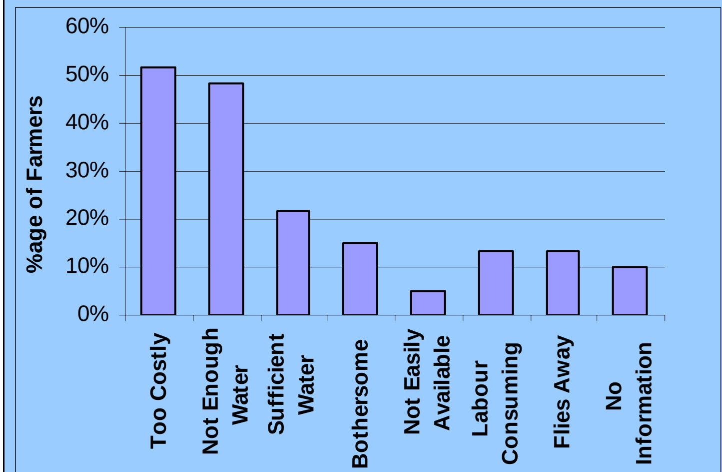


Figure 120: Reasons for not purchasing *Pepsee* Systems

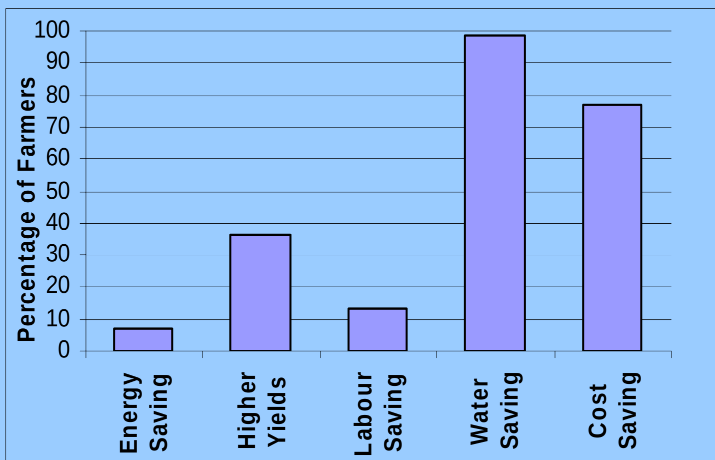


Figure 21: Reasons for Purchase of *Pepsee* Systems (Source: Primary Survey, 2002)

Our survey of 180 farmers in Jalgaon and Maikaal regions revealed the factors behind purchase decisions regarding *Pepsee* systems. The most widely perceived reason to adopt *Pepsee* (98.33 percent of the farmers perceive this benefit) was the fact that it lead to significant water saving at the farm level. The fact that *Pepsee* provides the benefits at less than half the price of micro-tubes and at one-fourth of the price of conventional drip systems (76.67 percent) gives *Pepsee* a niche in the market and was a significant factor in the farmers' decision making process. Other reasons for purchase included higher yields (36.50 percent), labour saving (13.33 percent) and energy saving (6.67 percent).

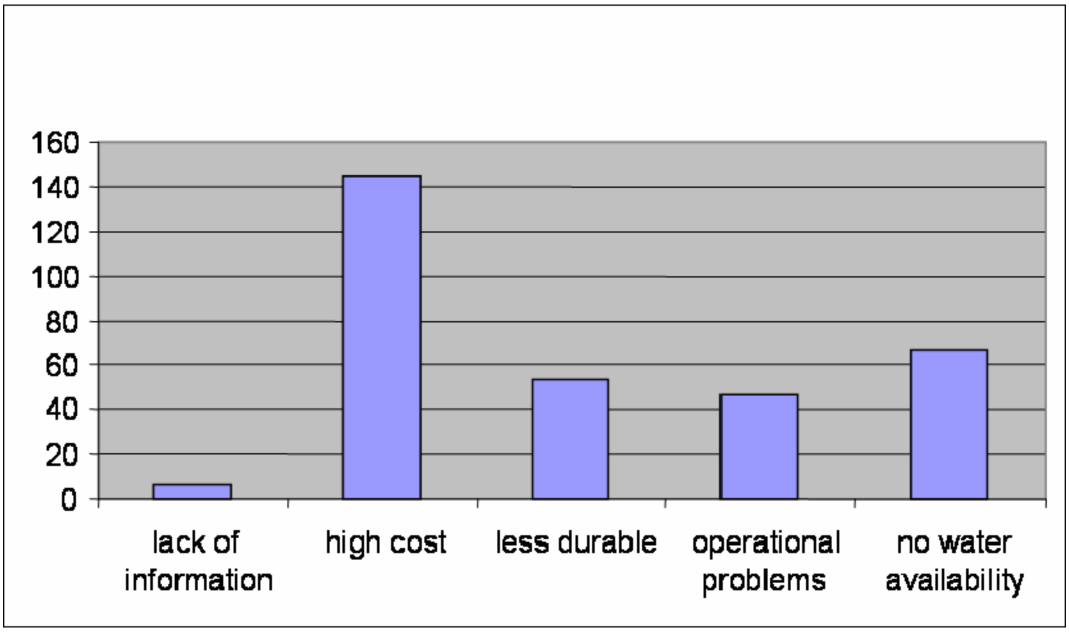
Surprisingly, even at these low costs, majority (51.67 percent) of the non-adopters feel that the technology is

[10] Verma, Tsephal and Jose (2004)

too costly. While another significant chunk of non-adopters (48.33 percent) complained that they did not have enough water to irrigate their fields even with the reduced water requirements in *Pepsee*. Near twenty-two percent of the non-adopters felt that they have sufficient water for their crops and hence did not feel the need for water saving. This is bound to change in the years to come. Fifteen percent of the non-adopters found the technology too bothersome. This can be interpreted in two ways. One, it could be that the scarcity which they face, is not very great or two, it could be that they face shortage of labour in their family. Around ten percent of the non-adopters were either not aware of the innovation or did not have sufficient information about the technology. Another five percent complained that they had difficulties in access to the market for this technology.

HINDRANCES IN ADOPTION OF DRIP IRRIGATION

Figure 22: Stated Hindrances for Adoption of Drip Technologies (Number of responses)

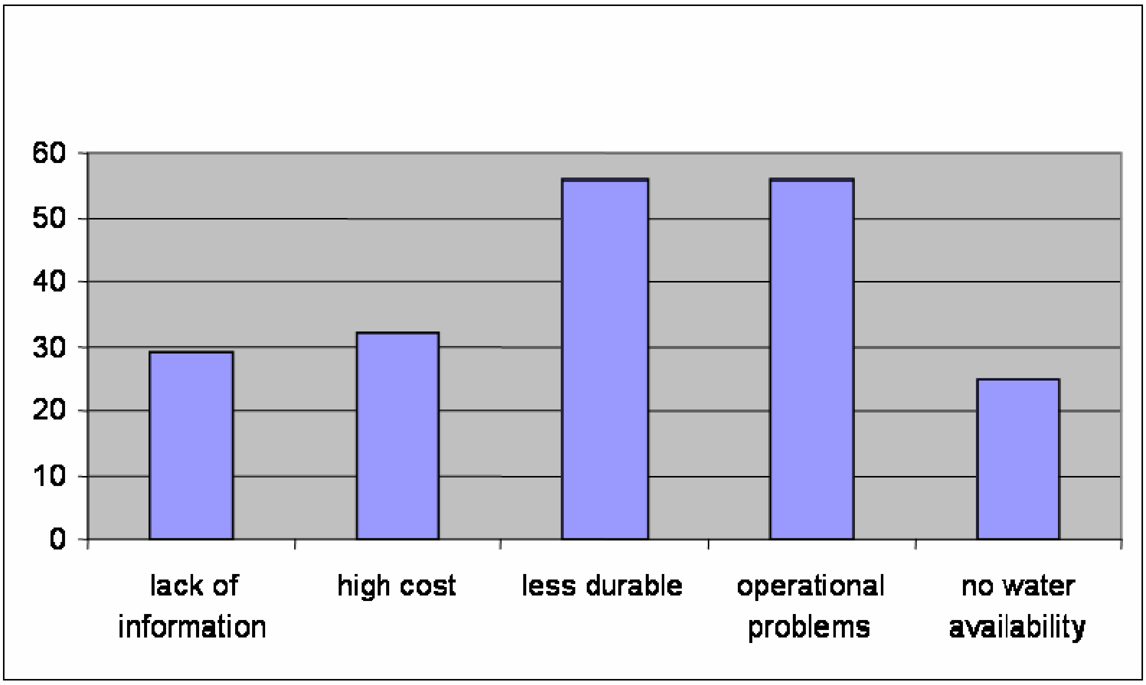


SEP survey (2003)

[11] Verma, Tsephal and Jose (2004)

HINDRANCES IN ADOPTION OF DRIP IRRIGATION

Figure 23: Stated Hindrances for Adoption of Pepsee (Number of responses)



SEP survey (2003)

The major hindrances for adoption of drip irrigation technology are the high initial investment involved. Thus small farmers having small landholdings do not prefer drips. While in case of *Pepsee* the lack of durability is the prime hindrance in its adoption, as perceived by the farmers. Even though *Pepsee* is a cheaper option compared to micro-tubes and conventional drip systems, there are many operational problems associated with it which hamper the large scale adoption of *Pepsee* among the farmers. These include maintenance of *Pepsee* kits, choking of pipes, bursting of pipes and tubes flying off in situations of strong winds. Thus there is a need to train the farmers in best practices in the use of drip irrigation as well as look into the quality aspects of drip kits which will lead to adoption of this technology in a large scale. In both the technologies, we find that not enough water is a problem with many farmers. This shows that there is a threshold level of water availability below which the farmer will not be able to adopt these water saving technologies.

SECTION VI: MESO AND MACRO LEVEL IMPACTS

VI.1 Spread of Organic Farming in Maikaal

While bioRe members have grown to around 1400 over the past decade, this is still only a small proportion of the total farming population of the region. Nevertheless, the Maikaal bioRe project holds the distinction of being the largest project of its kind in the world. But the impacts of the project are not restricted to the member households only. There are several indirect impacts which the project has created. First, and possibly the most significant indirect impact of the project have been on the increased awareness and concern among all farmers (members as well as non-members) about the possible perils of un-checked input intensification. bioRe has created a demonstration of an alternative farming philosophy and system which promises to potentially make the cropping system of adopters more beneficial and sustainable.

Yet, as the survey results on reasons for adoption show, the prime movers of the spread of organic cotton have been economic rather than a buy-in of the organic philosophy. So much so, that the success of bioRe has prompted two private companies to initiate organic cotton projects of their own. This, we believe, is the biggest indicator of the success of the initiative and the economic promise it offers. Besides the two new initiatives that have come up in the region, it has been found that even the non-adopters have reduced their fertilizer and pesticide consumption. This is a faint indicator that the innovation is being seen as a sound business proposition in the region.

VI.2 Spread of Micro-Irrigation Technologies in Maikaal

Has the adoption of water saving technologies lead to ‘real’ water saving at the meso-level? The answer to this question is fairly complicated. Our data clearly indicates that adoption of the technologies leads to improvements, though variable, in water-use efficiency at the farm level. Adopters are able to irrigate the same area with lesser quantity of water and/or are able to bring a larger area under irrigation. This, however, does not lead to water saving at the meso (basin) level. We found that water application per acre, as a result of adoption of *Pepsee*, for instance, reduced by roughly 50 percent. At the same time, on an average, the adopters were able to bring 2-3 additional acres of land under irrigation. Hence the saving in water is only ‘notional’ and not ‘real’ (i.e. saving per acre and per yield unit, but not in terms of reduction in pumping of groundwater).

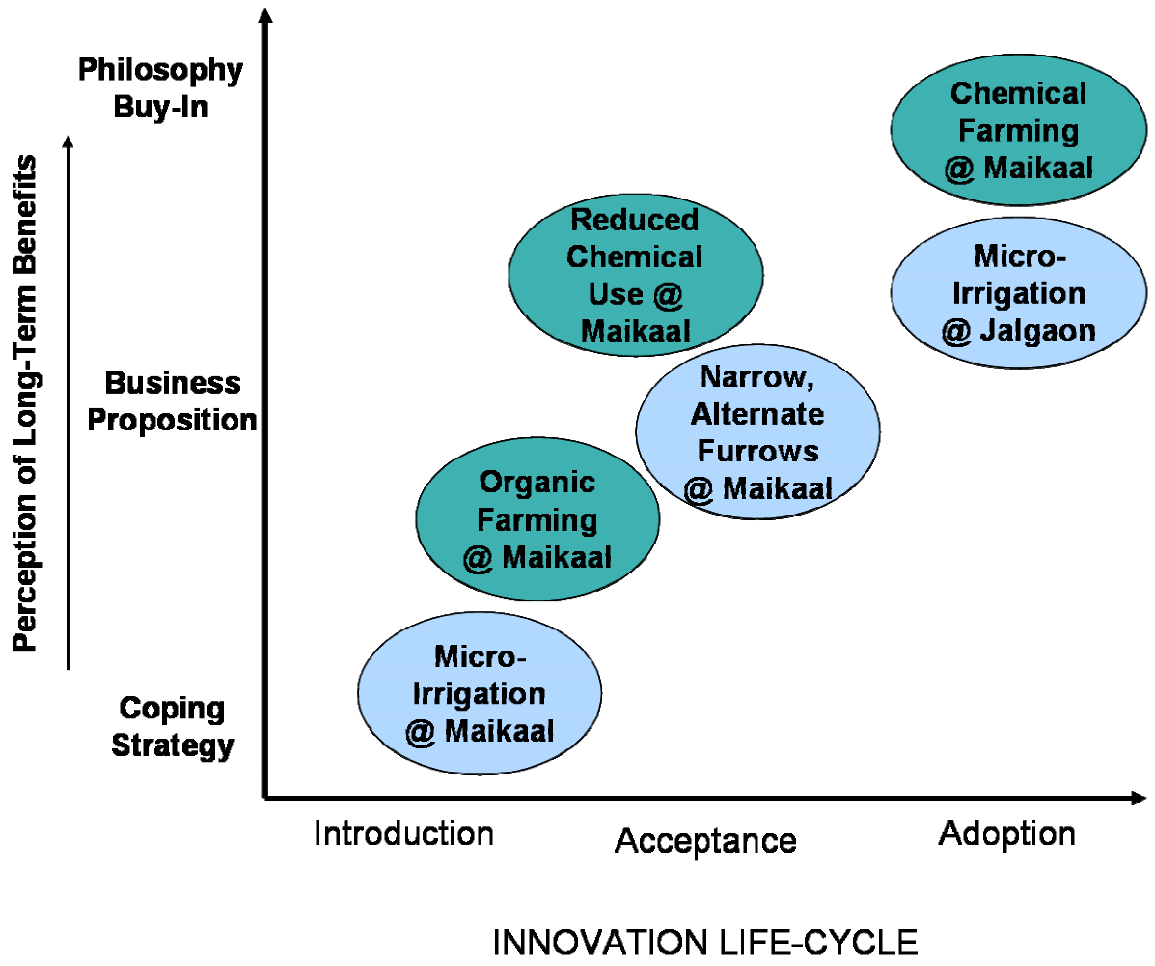
In certain cases, farmers who could not irrigate at all before adoption were able to irrigate their cotton crop as a result of adoption. This meant another increment to the net withdrawal of water from the aquifer. In fact, one of the prime hindrances for adoption is that some farmers do not have sufficient water to irrigate their crop even with adoption. Moreover, several farmers used these technologies only for pre-monsoon sowing of cotton and abandoned its use in the post-monsoon season when there was sufficient water available in their wells. This also indicates that the technologies are at a nascent stage. In other areas, like Jalgaon in Maharashtra, where the technologies have been established for well over a decade now and are popular among almost all farmers, farmers continue to use these technologies even when they have sufficient water in their wells to flood irrigate their crops.

Thus the adoption of these technologies has definitely led to more efficient utilization of water but, at the current level of adoption, might not lead to effective and sustainable management of the region's groundwater resources.

VI.3 Level of Adoption and Stages of Innovation Life-Cycle

The following diagram sums-up our understanding of the uptake of the two innovations in Maikaal and elsewhere. The diagram is not based on the results of our survey but pictorially represents how we see the two innovations in the context of scaling up.

Figure 24: Stages of Innovation Life-Cycle



As an innovation (product or process innovation) moves along stages in its life cycle (from introduction to acceptance and finally to adoption), the perception among the adopters about its benefits also changes. Generally, in early stages of adoption, the innovation is chosen for its more immediate and urgent benefits. Often, the early adopters are either those who are very enterprising and are willing to aggressively pursue new ideas as business propositions or those who are pushed the most against immediate situations and scarcities. In the latter case, which we believe is more common in the case of both the innovations in question here, the innovations are largely viewed as coping strategies for short-term scarcities (declining areas under irrigation due to water and power scarcity in the case of water saving technologies and accumulating debts and working capital shortages in the case of organic farming). Unless the nature of product is so or special efforts are made by an agency (external or from within the social group) to create distinct advantages for early adopters, the innovations do not take-off. For example, when pump technology first came into Maikaal, there was an inbuilt first-mover advantage for early adopters as they could sell water to non-adopters and earn a margin. Likewise, when bioRe promotes organic farming in Maikaal, it plays the role of an external agency which tries to create incentives for people who take up the innovation.

Referring back to the diagram, both the innovations are yet to mature into a stage where they would become the dominant philosophy of farming in the region. In the case of micro-irrigation, this is clear from the behavior of farmers. They use *Pepsee* or drips largely for pre-monsoon sowing and when there is enough water available in the wells in the post-monsoon season, most farmers remove the drip kits from their fields and revert back to furrow irrigation. The perception of benefits is another indicator of the level/stage of innovation take-off. We compared the perceived benefits of precision irrigation between adopter-farmers in Maikaal and Jalgaon and found that farmers in Jalgaon use their drip kits even when they have sufficient water in their wells because they believe that the use of drips gives them better quality and higher yields. In the case of Maikaal, however, the dominant reason for adoption is the increase in area under irrigation. Hence while micro-irrigation adoption has reached a stage where it is viewed as a business proposition in Jalgaon, it is still perceived more of a coping strategy in Maikaal (as also in south Gujarat, where the dominant reason for adoption is salinity control).

It must be noted here that the above framework presumes a crucial parameter for adoption of micro-irrigation. We found that some of the non-adopter farmers did not even have the minimum threshold level of water availability to be able to adopt these technologies. In such cases, unless access to some water is ensured through support for digging a new well/tube-well or Narmada pipelines, the farmer will not be in any position to adopt the technologies. It is also interesting to find almost all farmers in Maikaal practicing furrow irrigation and several farmers using alternate and narrow furrows. These technologies have reached a stage of acceptance and a large majority of the farmers are willing to experiment with them. The reasons for the take-off of these innovations could be that they require no cash/capital investment (which is one of the biggest hindrances in adoption of other water-saving technologies) and that there have been sufficient demonstrations and dissemination of their benefits through (possibly) the most effective channel of farmer-to-farmer communication.

Likewise, we found that several non-adopters of organic farming have also reduced their consumption of chemical inputs. Though, they are apprehensive about a total shift to organic agriculture. Thus chemical farming continues to be the dominant philosophy of the region and it will take some time and effort before it becomes a business proposition and farming philosophy. In the next section, we discuss some issues of concern for the promoters of these two innovations and some of the lessons which the research throws-up for them.

SECTION VII: OBESERVATIONS AND SUGGESTIONS

VII.1 Promoting Water Saving Technologies

Promoting micro-irrigation as ‘water saving’ technologies has not worked in India. Despite active promotion by a growing private irrigation equipment industry and subsidies provided by the state, the appeal of these technologies has remained confined to “gentlemen farmers”. Our work in Maikaal, as well as in north Gujarat, Saurashtra and Jalgaon indicates that in all these places the technology has been adopted for reasons other than water saving. Adoption in Jalgaon was induced by yield enhancement benefits, labor scarcity, inconvenient hours of power supply and the complimentarity with technologies like tissue culture in Banana cultivation. Like-wise, in Saurashtra (south Gujarat), the quality of water (salinity) was a major motivation. Farmers in Maikaal have taken to *Pepsee* and drips primarily to increase the area under irrigation.

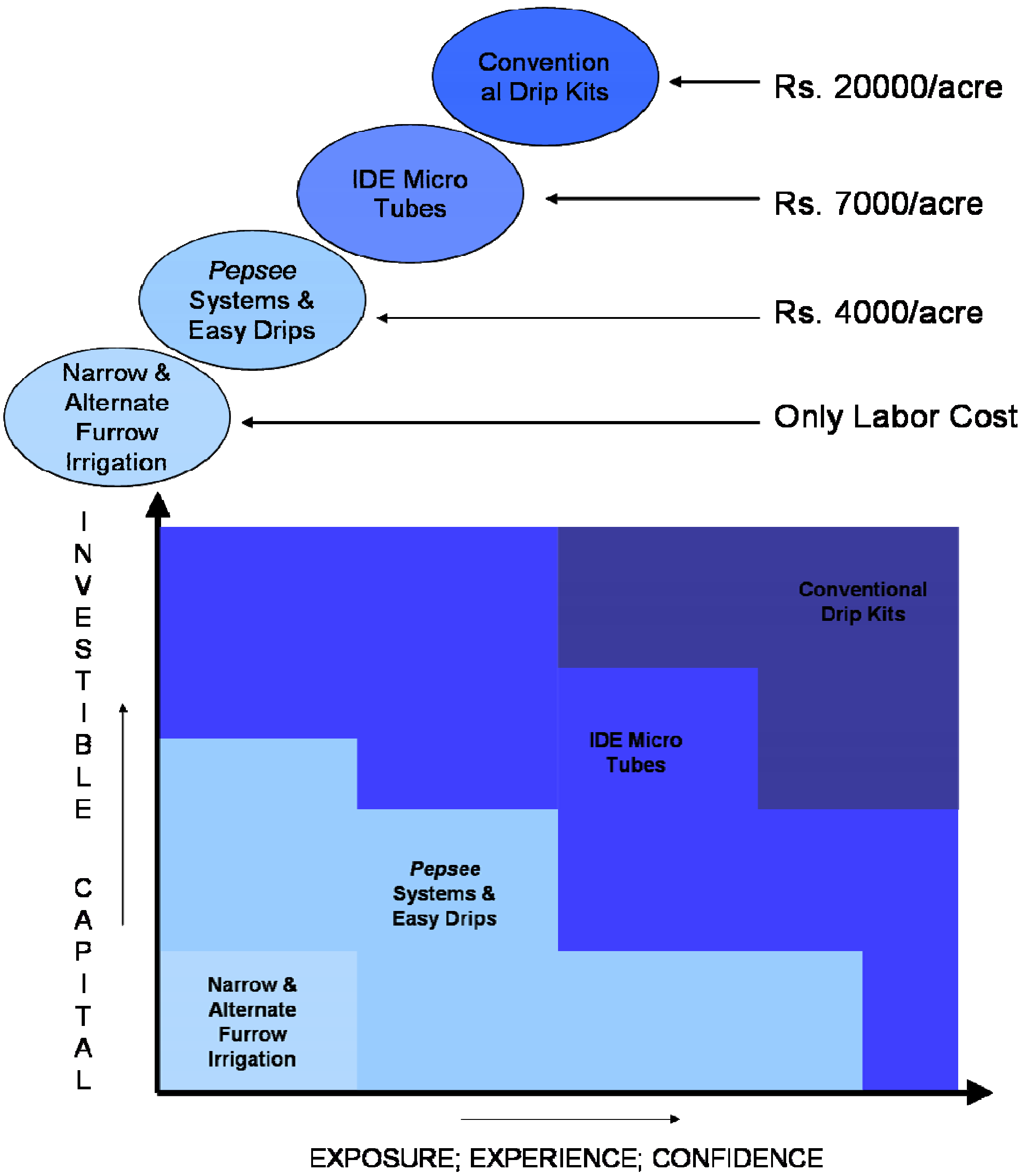
The issues to be addressed in this respect are as follows:

- Shifting Water Saving Technologies from Investment Mode to Input Mode: There is a need to view water saving technologies as recurring but much lower input costs rather than capital investments that offer returns over the next 8-10 years. If the small farmers, who are the largest chink of the potential market, are to be targeted, policy makers and promoters must understand that they would be hesitant in making huge-capital investments in new technologies unless they are very sure of their results. Even when they are convinced about the returns, they might not be in a position to incur the huge capital costs due to poor access to good quality credit options. It is therefore important to encourage ‘stepping stones’ such as *Pepsee* and easy drip to help the farmer make the transition.

- Creating ‘First Mover Advantage’: Unlike in the case of pump technology, where being the first adopters meant that one could skim the market by selling water to other, there do not seem to be any apparent first mover advantages in the adoption of micro-irrigation. Almost each farmer would tend to wait for others in the village or neighborhood to try out and test the new technologies first and prove to all, at their risk, the reliability of the technologies. In such a scenario, it makes sense to provide special incentives to ‘first movers’. This can and is already being done in two ways. One way, as being done in IWMI’s North Gujarat Initiative in Banaskantha, is to become the first mover by creating demonstrations in the area and letting the farmers see for themselves what works and what does not. This will also help in exposing the farmers to several types of micro-irrigation technologies. Two, as is being done by AKRSP (I) in Saurashtra, is to provide higher subsidies (or other support) to early adopters and gradually reduce the amount of subsidies (or the degree of support) over the years and with expansion.

- Choosing the Right Technologies: There is a wide range of water saving technologies available in the market today and it is often confusing both for promoters like bioRe as well as for the farmers on how to choose a particular technology which would most suit their specific requirements. *Pepsee* systems are not complete substitutes for the highly sophisticated custom-made conventional drip irrigation systems. Even our financial calculations and survey results indicate that the returns offered by micro-tubes and conventional drips are higher that those offered by *Pepsee*. However, if *Pepsee* systems and easy drips are viewed as ‘Stepping Stone’ technologies, the results can be very positive. In our survey in Jalgaon and Maikaal, 6 of the 8 farmers who discontinued the use of *Pepsee* after one-two years shifted to IDE’s micro-tubes. Thus, there are indications that as the farmers get convinced about the results, become familiar with the technology; and possibly also improve their financial status in the process; they would shift to the more efficient technologies being marketed today. We present a simplified illustration of how such logic can help us in identifying the right technology.

Figure 25: Water Saving Technologies and Target Groups



Note: The illustration assumes land and water availability beyond a minimum threshold level and suggests that farmers are more likely to adopt lower-cost input-mode technologies such as *Pepsee* and Easy Drips at lower levels of exposure, experience and confidence with the technologies.

VII.2 Tapping the Synergies between the two Innovations

While there did not seem to be any direct linkages between the adoption behaviors of farmers for the two innovations, there do seem to be certain synergies that can be tapped which would lead to a faster up-take of both the innovations. There were 42 farmers in our SEP sample who had adopted both water saving technologies as well as organic farming.

As our data on cotton crop economics indicates, there are significant benefits which organic farmers can receive (in terms of price of cotton) if they are able to sow their cotton crop in the pre-monsoon season. The benefits of organic farming adoption seem to get multiplied when coupled with adoption of micro irrigation technologies. This is because of the fact that the production cost in case of organic farmers and drip farmers is less than that of chemical farmers and conventional farmers respectively. If we take into account the fact that adoption of drip will, on an average bring an additional 2.2 acres of land under irrigation, the total benefits from adoption of Organic farming and drip irrigation will get multiplied.

The following table summarizes the results and reiterates the potential benefits from twin/joint adoption of the two innovations.

Table 23: Tapping the Synergies between the two innovations

	Average Price/Quintal	Average Yield/Acre	Average Costs/Acre	Average Profit/Acre	**Incremental Gain**
Chemical Farmers without Drip Adoption	2569.51	4.27	4152.08	6331.52	
Chemical Farmers with Drip Adoption	2764.55	3.82	3893.69	7385.67	**16.65**
Organic Farmers without Drip Adoption	3083.41	4.35	3600.74	9257.09	**29.56**
Organic Farmers with Drip Adoption	3317.46	3.94	3600.74	10233.07	**15.41**

References

GoMP. (1974). West Nimar: Madhya Pradesh District Gazetteers, District Gazetteers Department, Government of Madhya Pradesh, Bhopal.

Verma, S., Tsephal, S. and Jose, T. (2004). *Pepsee* systems: grassroots innovation under groundwater stress. *Water Policy*, Vol. 6:4 pp 303-318.

Umesh, R. and Kumar M. D. (2003). *When farmers adopt water saving technologies?: Findings of a market research study from north Gujarat*. Paper presented at the Annual Partners' Meet of the IWMI-Tata Water Policy Program, Anand, 27-29 January.

Kumar, M. D., Shah, T., Bhatt, M. and Kapadia, M. (2004). *Dripping Water to a Water Guzzler: A Techno-Economic Evaluation of the Efficiency of Drip Irrigation in Alfalfa*. Paper presented at the Annual Partners' Meet of the IWMI-Tata Water Policy Program, Anand, 17-19 February.

Sharma. K. G. (March 1997). *Variations in Estimates of Cotton Production (A Study in Khandwa, Khargon and Dhar Districts of M.P).* Agro-Economic Research Centre for Madhya Pradesh, JNKVV, Jabalpur.

Kale. A.M. (2003). *Towards Raising of Organic Cotton.* The Maharashtra Co-operative Quarterly. (October-December 2003)

Gajbhiye. Hemachandra and Mayee. C. D. *Organic Cotton: A Niche Market or a Must Market.* Indian Journal of Agricultural Marketing, 15 (2) 2001.

David. Shourie. G. and Sai. Y. V. S. T. *Bt Cotton: Farmers' reactions.* Economic and Political Weekly, November 16, 2002

Dr. P. K. Ghosh*. Indian Experiments on Bt Cotton.* Agro India. (April 2000)

Gulati. Ashok. *Effective Incentives and Subsidies for Cotton Cultivators in India*. Economic and Political Weekly. (December 26, 1987)

Meena. Menon. (2003) *Organic Cotton: Reinventing the Wheel, A Compilation by Meena Menon.* Deccan Development Society, Kalpavriksh.

Dankers. Cora. et. al. (2003). *Environmental and Social Standards, Certification and Labelling for Cash Crops.* Food and Agricultural Organisation of the United Nations, Rome, 2003.