ECONOMICS OF DRIP IRRIGATED COTTON: A SYNTHESIS OF FOUR CASE STUDIES

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Abstract

Studies on different crops confirm that drip method of irrigation saves substantial amount of water, increases productivity of crops as well as reduces cost of cultivation. However, detailed studies are seldom available about the economics of cotton cultivation under drip method. Therefore, an attempt is made here to find out the impact of drip irrigation on various parameters including its economic viability. The study shows that cultivating cotton under drip irrigation provides a number of different benefits to farmers over the conventional flood method of irrigation. Drip irrigation reduces cost of irrigation by about 50% and helps reduce the cost on weeding, interculture and preparatory works. Water saving in drip irrigation in cotton cultivation is estimated to be about 45% of flood irrigation. This also saves the consumption of electricity by about 140 Kwh/acre compared with flood irrigation. The productivity of drip-irrigated cotton is about 114% higher than the corresponding flood irrigation harvest. The profit of the cotton crop cultivated using drip irrigation is higher by about Rs. 20601/acre than the corresponding profit realised by flood irrigation. The net present worth and benefit-cost ratio estimated using discounted cash flow technique shows that the investment in drip irrigation is economically viable even without subsidy. The analysis also shows that the farmers would be able to repay the whole capital cost of drip system from the income generated in the very first year of raising the crop.

1. INTRODUCTION

The intensification of agriculture along with increased demand for water from other sectors has put tremendous pressure on the limited water resources in recent years in India. An estimate by the Central Water Commission (CWC) shows that by 2050, the annual requirement of water from all sectors (1447 BCM) would exceed the annual utilisable water from both surface and groundwater sources in India (1122 BCM) (CWC, 2005).[1]

While the available fresh water supplies for future use have been declining at a faster rate, the requirement of food and other agricultural commodities has been on the rise because of continuous population growth and feed requirement for livestock (see, Bhalla, et al., 1999; Amarasinghe, et al., 2007; Chand, 2007). Since irrigation contributes substantially to the gross production of agricultural commodities, the fast increase in demand for irrigation water puts enormous pressure on policy makers to find ways to improve agricultural production while economising irrigation water. The conventional method throughout the world for crop cultivation is flood irrigation. It is inefficient in terms of field application efficiency and eventually the overall water use efficiency as it allows heavy losses of water through conveyance and distribution (Shreshtha and Gopalakrishnan, 1993; Rosegrant and Meinzen-Dick, 1996; Rosegrant, et al., 2002; Postal, 2001). Quite a few supply side efforts have been made to increase the water use efficiency under flood irrigation method (FIM) in India and elsewhere in the world. However, those efforts and strategies have not made any significant impact on the overall water use efficiency in both canal and groundwater irrigation.

Drip irrigation method (DIM) is a technical measure introduced about two decades back to increase the water use efficiency in Indian agriculture[2.] Under this method, water is delivered directly to the root zone of the crops using pipe network and emitters. This method is entirely different from the conventional method,

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where water is dispersed to the whole cropland, instead of exclusively to the crop. Since water is supplied at the required time and the required quantity using pipe network, excess irrigation as well as water losses occurring through conveyance and distribution are eliminated. Experiment based studies show that the water use efficiency can be achieved upto 100% under DIM, whereas the same is possible only in the range of 35-40% under flood method of irrigation (INCID, 1994; Sivanappan, 1994). Besides saving water, DIM is also capable of enhancing crop productivity at low cost of cultivation (Narayanamoorthy, 1997, 2004 and 2005; Dhawan, 2002).

DIM is a relatively new method of irrigation. It entails relatively large amount of fixed capital investment. Therefore, several studies have been carried out to find out the impact of DIM on different parameters of crop cultivation including its economic viability in different crops, using both experimental and field level data (see, INCID, 1994, Narayanamoorthy, 1997; 2003, 2004; Dhawan, 2002). Studies especially carried out using field survey data on crops such as banana, grapes and sugarcane have showed that the DIM saves water by about 30-40%, increases productivity by 30-45% and considerably lowers the cost of cultivation compared to the same crops cultivated under FIM with similar environment. Studies have also showed that investment in drip irrigation is economically viable for farmers even without subsidy (see, Narayanamoorthy, 1997, 2004 and 2005).

Though studies on the impact of DIM on many other crops are available, studies on cotton cultivation under DIM using field level survey data are seldom available especially on the Indian context.[3] Cotton is an important commercial crop cultivated in India covering an area of about 8.68 mha in 2005-06 (GoI, 2007). Though cotton is predominantly cultivated as a rainfed crop, about 33% of the cotton area is cultivated under surface irrigation method in India. Because of inherent problems associated with the surface irrigation and increased water scarcity, farmers are not able to supply water at the required time interval for cotton, which increases the moisture stress on crops. As a result, farmers are not able to increase the productivity of the crop despite using required yield-increasing inputs, The productivity of cotton crop is one of the lowest in the world.[4] The experimental data based studies carried out in different locations show that cotton cultivated under DIM increases productivity by about 25% and water saving by 60% (INCID, 1994). Realising the importance of DIM on water saving and productivity, farmers in different parts of India have started adopting it especially in the recent years. Why do farmers cultivate cotton crop under DIM? What is the main driving force for the increased adoption of DMI in cotton cultivation? What is the impact of DIM on water saving and productivity of cotton? Is the investment in drip irrigation economically viable for farmers without subsidy? What is the pay back period of drip investment in cotton cultivation? Since studies focusing on these issues using field level survey data are not available, this study makes an attempt to fill this void using the data collected from farmers cultivating cotton in Maharashtra state. The specific objectives of the study are: (1) To find the operation-wise cost saving due to drip method of irrigation in cotton cultivation. (2) To estimate the water and electricity saving due to DIM in cotton cultivation. (3) To study the impact of DIM on the productivity of cotton crop. (4) To study the relative economics of drip and non-drip irrigated cotton crop. (5) To estimate the economic viability of drip investment with and without capital subsidy under different discount rates assuming different life periods of the system.

2. EMPIRICAL SETTINGS AND METHOD

This paper is a synthesis of in-depth case studies[5] of four individual farmers selected from Jalgaon district of Maharashtra, an important cotton-growing state accounting for about 33% of India's total cotton area during 2005-06. Severe groundwater scarcity along with frequently interrupted supply of electricity have forced the farmers to cultivate cotton under drip method of irrigation in certain parts of Maharashtra state in the recent years. Jalgaon, a district in the north-western part of Maharashtra has been selected for this study to capture the impact of drip irrigation on various parameters of cotton cultivation. From three different villages[6], we have selected four farmers each with different land holding sizes cultivating uniform variety (Bt cotton) of cotton under both drip and flood method of irrigation. This is done to moderate the impact of soil and other environmental factors on water consumption and productivity of crop. In addition to in-depth discussions with the selected farmers on the cultivation of cotton under drip irrigation, all the data associated with cotton cultivation pertaining to the agricultural year 2006-07 have been collected from the farmers to carry out a detailed analysis and make a comparison between the crops under drip and flood irrigation.

In order to find out the economic viability of investment in drip irrigation in cotton cultivation, both net present worth (NPW) and benefit-cost ratio (BCR) are estimated using discounted cash flow technique (Gittinger, 1984). INCID (1994) study assumed 5 years as a life period of the drip set for computing the benefit-cost ratio of cotton crop under DIM. However, the experiences of the farmers cultivating cotton in the study area under DIM and the sources from drip industry seem to suggest that the drip system can last up to 15 years without incurring any heavy cost on operation and maintenance. Therefore, NPW and BCR are computed separately treating 5, 10 and 15 years as life period of the drip system. Though the rate of interest for institutional credit is currently around 10%, we have estimated NPW and BCR separately keeping 10% and 15% discount rates.

The NPW is the difference between the sum of the present value of benefits and that of costs for a given life period of the drip set. It collates the total benefits with the total costs taking into account items such as cost of capital and depreciation costs of the drip set. As per the NPW criterion, the investment on drip set can be treated as economically viable if the present value of benefits is greater than the present value of costs. The BCR is closely related to NPW as it is obtained by dividing the present worth of the benefit stream with that of the cost stream. If the BCR is more than one, then the investment on any project can be considered as economically viable. Obviously, a BCR greater than one implies that the NPW of the benefit stream is higher than that of the cost stream (Gittinger, 1984). The NPW and BCR are mathematically defined as follows:

$$NPW = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} \quad \ldots\ldots (1)$$

$$BCR = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}} \quad \ldots\ldots (2)$$

[Where, B_t = benefit in year t; C_t = cost in year t; t = 1, 2, 3,…….n; n = project life in years;i = rate of interest or the assumed opportunity cost of the investment]

Drip irrigation involves fixed capital and thus, it is necessary to take into account the income and cost stream for the whole life span of drip investment. However, it is difficult to uncover the actual cash flows for the entire life span of drip investment because of the absence of observed temporal information on benefits and costs. So, we have made a few realistic assumptions to estimate both the cash inflows and cash outflows for drip investment. These assumptions are:

1. The life period of the drip set is assumed to be 5, 10 and 15 years, and on that basis, three different NPW and BCRs are worked out.
2. The cost of cultivation and income generated using drip method of irrigation is assumed constant during the entire life period of drip set.
3. Two different rates of discount (interest rates) are considered to understand the sensitivity of investment to the change in capital cost. They are assumed at 10 and 15% as alternatives representing different opportunity costs of capital.
4. The cultivation technology of cotton crop is assumed to remain constant during the entire life period of drip set.

3. COST OF CULTIVATION

While saving water and increasing productivity of crops, DIM reduces the cost of cultivation especially in operations like irrigation, weeding, ploughing and preparatory works. To understand the impact of DIM on various operational costs of cultivation, we have compared the costs of each of the operations for drip and flood irrigated crop. The data on operation-wise cost of cultivation presented in Table 1 show only a marginal difference in the total cost of cultivation[7] between the two methods. However, when we exclude the harvesting cost from the gross cost of cultivation, the overall cost saving due to DIM comes to nearly 17% over FIM. Harvesting cost is directly associated with the yield of cotton, and as the yield of crop cultivated under DIM is substantially higher, cost incurred by the farmers on account of harvesting is necessarily higher for DIM crop.

Table 1: Operation-wise cost of cultivation of drip and flood irrigated cotton (Rs/acre)

Sr. No.	Operation	DIM	FIM	Gain over FIM	
				Amount	Percent
1.	Preparatory works	950.00	1537.50	587.50	38.20
2.	Seed and seed sowing	1020.00	1020.00	0.00	0.00
3.	Fertilisers	2042.25	1868.50	-173.75	-9.30
4.	Farm yard manures (FYM)	2750.00	2750.00	0.00	0.00
5.	Pesticides	3750.00	4750.00	1000.00	21.05
6.	Weeding and interculture	290.00	490.00	200.00	40.80
7.	Irrigation	864.60	1773.10	912.50	51.40
8.	Harvesting	5200.00	2500.00	-2700.00	-108.00
9.	Others	537.50	500.00	-37.50	-7.50
	Total cost	17404.40	17193.10	-211.20	-1.20
	Total excluding harvesting cost	12204.40	14693.10	2488.80	16.90

Source: Case study data.
Note: Operation-wise cost includes both inputs and labour cost (i.e., cost A2+FL).

As confirmed by earlier studies on other crops, among the various operations, substantial cost saving is noticed in operations like irrigation[8] (51%), weeding and interculture (about 40%) and preparatory works (about 38%). While the reduced consumption of water under DIM reduces the cost on irrigation, relatively fewer requirements of ploughing and other preparatory works for cultivating crop under DIM. Since water is supplied only at the root of the crops and not to the non-crop zone, weed growth is reduced substantially, which eventually reduces the labour requirement for weeding and interculture operation in cotton cultivation. Interestingly, we did not observe substantial difference in the use of yield increasing inputs such as fertilisers, FYM and pesticides between the two methods of irrigation. This seems to suggest that the farmers are not discriminating the crops in terms of adoption of yield-increasing inputs while cultivating cotton under FIM or DIM. There is little difference in the gross cost of cultivation for drip and non-drip irrigated crop.

4. WATER AND ELECTRICITY SAVING

Applied water saving and electricity saving are two significant advantages of drip method of irrigation. Since water is supplied directly to the root zone of the crop under DIM, substantial amount of water losses occurring due to conveyance, distribution and application at the field level are reduced. Under experimental based studies, water consumption is usually estimated as depth of water applied (in terms of cm or mm). But, the same method is difficult to follow at the farmers' field because of changes in the horse power (HP) of the pumpset, water level in the well, varying level of delivery pipes, condition of the water extraction machineries, distance between place of water source and field to be irrigated, quality of soil and terrain condition. In view of this, we have measured water consumption in terms of horsepower (HP) hours of irrigation. HP hr of water consumption is computed by multiplying HP of the pump-set with hours of water used by each farmer.[9]

The data presented in Table 2 illustrates that water saving is substantial due to the use of drip method of irrigation in cotton cultivation. Though the number of irrigation used for drip irrigated crop (57.50) is substantially higher than that of flood irrigated crop (8.50), the hours used for each turn of irrigation is less than 1 hr (only about 0.48 min.) under DIM as against the use of 9.45 hr/acre under FIM. As a result, the total water used for drip-irrigated cotton comes to about 228 HP hours/acre, whereas the same comes to about 415 HP hours for non-drip irrigated cotton crop. This means that farmers are able to save about 187 HP hr of water per acre, which is about 45% saving over FIM. The main reason for substantial water saving under DIM is that the farmers are able to supply required quantity of water at the required time exclusively at the root zone of the crop. This, the farmers are unable to accomplish when cotton is cultivated under flood method of irrigation. Though the water used under the FIM is much higher than under the DIM, farmers following FIM reported that they were not able to supply adequate quantity of water during the time of crop growth mainly due to water shortage in the well and frequent interruptions in electricity supply. Therefore, their cotton crop had to face either moisture stress or excess wetting throughout the crop season, which has significant impact on crop growth. In fact, all farmers reported frequent interruptions in electricity supply and water scarcity as 2 of the prime reasons for adopting the DIM for cotton cultivation.

Table 2: Water and electricity consumption in drip and flood irrigated cotton (Rs/acre)

Sr. No.	Particulars	DIM	FIM	Gain over FIM	
				Amount	Percent
1.	Pumpset HP	5	5	—	—
2.	Number of irrigation/acre	57.50	8.50	-49.00	-576.50
3.	Hours per irrigation/acre	0.48	9.45	8.57	94.92
4.	HP hours of water used/acre	228.10	415	186.90	45.00
5.	Electricity consumption (kwh/acre)	171.10	311.25	140.15	45.00

Source: Case study data.
Note: Operation-wise cost includes both inputs and labour cost (i.e., cost A2+FL).

The water saving estimated here is the applied water saving at the field level. However, to what extent this gets converted into real water saving depends on what portion of the applied water in the case of FMI which gets depleted. As Kumar et al., (2008) noted, the real water saving at the field level through micro irrigation systems would be determined by the crop type, groundwater environment and the climate. It would be significant for row crops in semi arid and arid climatic conditions, with deep groundwater table. This is because the non-beneficial evaporation from soil (not covered by canopy), and non-recoverable deep percolation would be substantial. In our case study, the cropped area not covered by canopy cover is large, especially during growing season, the area has semi arid climate, and groundwater table is deep. Therefore, the applied water can be treated as very close to depleted water in case of FMI.

The irrigated area can be expanded using the saved water by the drip method of irrigation. Farmers have reported that they have brought additional area under irrigation by adopting drip irrigation. An important policy related question associated with DIM is how much additional area can be brought under cotton cultivation from the water saved in using DIM. Our estimate suggests that the water saving gained from an acre of cotton cultivated using DIM will enable a farmer to bring additional 0.82 acre under cotton cultivation.

The reduced consumption of water by drip-irrigated crop obviously curtails the working hours of pumpset reducing the required quantum of electricity. We have attempted to estimate the electricity saving in cotton cultivation. It is calculated that 0.750 kwh of power is used per HP for every hour of pumpset operation (see, Shah, 1993). So, we have multiplied the HP hr of the pumpset with assumed power consumption to estimate the electricity requirement for an acre of cotton cultivation (see, Table 2). As per our estimate, the consumption of electricity under DIM is only about 171 kwh/acre as against 311 kwh/acre under FIM, a saving of 140 kwh/acre.

Table 3: Productivity of drip and flood irrigated cotton (Rs/acre)

Sr. No.	Particulars	DIM	FIM	Gain over FIM	
				Amount	Percent
1.	Productivity (qtl/acre)	18.25	8.50	9.75	114.70
2.	Cost of production (Rs/qtl)	953.70	2022.70	1069.00	52.85
3.	Water productivity (kg/HP hour of water)	7.99	2.05	5.90	289.75
4.	Electricity productivity (kg/kwh)	10.67	2.70	7.90	290.80

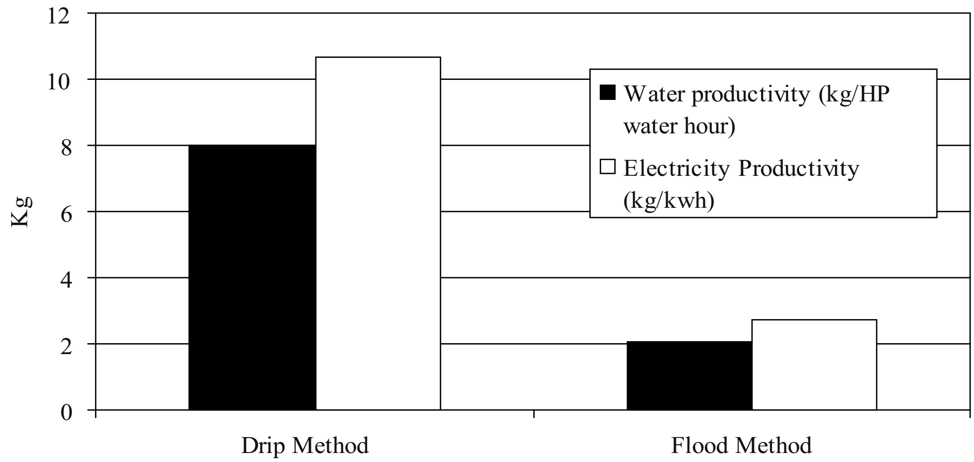
Source: Estimated using case study data.

5. PRODUCTIVITY GAINS

DIM is primarily introduced to increase water use efficiency. In addition, it considerably increases the productivity of crops by reducing their moisture stress. Data presented in Table 3 shows that productivity of cotton cultivated under DIM (18.25 qtl/acre) is about 114% higher than under FIM (8.50 qtl/acre). What are the causes for this increased productivity of cotton under DIM? The farmers attribute yield increase to the following four reasons. First, under DIM the moisture stress for crop is avoided because of its ability to supply required quantity of water at the required time. This has increased the plant growth, increasing the number of canopies from which more flowers and bolls are produced. Second, supply of water only at the root zone of the crop prevents water flow to other zones where the weeds grow and therefore, weed growth is reduced. Third, the supply of water at regular intervals also allowed the crop to absorb the fertilisers without any big losses through leaching and evaporation. Fourth, pre-mature dropping of bolls is reported to be less under drip method because of the absence of moisture stress as compared to FIM. We have not attempted to study the contribution of each factor on the productivity of cotton crop. However, taking into consideration the insignificant difference in the use of yield-increasing inputs between the crops cultivated under drip and flood method of irrigation, one might be inclined to attribute the whole productivity gain to drip irrigation.

The availability of water and electricity is becoming a serious constraint in countries like India in view of their intensifying demand. Therefore, along with land productivity, there is an urgent need to increase the productivity of these inputs (see, Kijne, et al., 2003). Since land productivity of cotton cultivated under DIM is very high over FIM, we have tried to estimate whether DIM also increases the productivity of water and electricity together with a reduction in cost of production. In order to identify the water and electricity productivity of cotton, we have estimated per unit productivity per HP hours of water, as well as per unit productivity per kwh of electricity. Under DIM, cotton productivity is 8 kg/HP hours of water whereas the same is only 2.05 kg for FIM crop. Similarly, electricity productivity (kg/kwh) is 10.67 for DIM crop and it is only 2.70 kg for FIM crop (see, Figure 1). The improved productivity due to DIM also enhances the cost efficiency significantly (the cost required to produce one unit of output). These results clearly indicate that DIM not only increases the land productivity but also increases productivity of water and electricity.

Figure 1: Water and electricity productivity under drip and flood irrigated cotton



6. RELATIVE LEVELS OF PROFIT OF COTTON CULTIVATION

Let us now turn our attention to the relative profit levels of cotton cultivated under the two methods of irrigation. While calculating profit of cotton per acre, the total cost is calculated considering only the variable cost and not fixed costs like interest rate and depreciation. The gross income from cotton is calculated by multiplying total yield with the price (which varied from Rs. 2000-2300/qtl) received by the farmers. In order to calculate the profit, the corresponding total cost of cultivation is subtracted from the gross value of production under DIM and FIM. The estimated profit per acre comes to Rs. 21283 for DIM, but is only Rs. 681 for FIM cotton.[10] So the profit of drip-irrigated cotton is higher by Rs. 20601/acre than flood irrigated cotton (see, Table 4)[11]. One may be interested to know whether higher profit is due to the effect of productivity or due to the effect of price. As mentioned in the methodology section, farmers selected for this study have cultivated uniform variety of cotton (Bt. cotton). Therefore, those farmers could get same price for the cotton harvested from drip and flood irrigated fields. This higher profit is purely because of yield effect under DIM and not because of price effect. Farmers can repay the whole capital cost of the drip system (which is about Rs. 21375/acre without subsidy) from the profit of a single crop in a year. This could be an important reason why farmers in the study area want to switch to DIM.

Table 4: Relative profit levels of drip and flood irrigated cotton (Rs/acre)

Sr. No.	Particulars	DIM	FIM	Gain over FIM	
				Amount	Percentage
1.	Gross cost of cultivation	17404.40	17193.10	-211.20	-1.20
2.	Gross value of production	38687.50	17875.00	20812.50	116.40
3.	Profit (farm business income)	21283.10	681.90	20601.25	3021.30
4.	Capital cost of DIS (without subsidy)	21375.00	—	—	—
5.	Subsidy for DIS (Rs/acre)	10631.25	—	—	—
6.	Capital cost of DIS (with subsidy)	10743.75	—-	—	—

Source: Case study data.
Note: DIS – drip irrigation system

7. BENEFIT-COST ANALYSIS

Gross profit (farm business income) of cotton cultivated under DIM is significantly higher than the gross profit under FIM. However, this gross amount cannot be treated as the effective (real) profit of cotton cultivated under DIM, since it does not take into account the capital cost of the drip set, its depreciation and interest accrued on the fixed capital. For calculating the net profit, they should all be taken into account. The longevity (duration of service) of drip-set is an important variable to determine the net present value, which in turn is a determinant of per hectare profit. DIM is a capital-intensive technique and therefore, the initial high investment needed for installing drip systems remains the main disincentive for the widespread adoption, especially in crops which are not water-intensive like cotton. To what extent this disincentive effect is real and to what extent such effect can be counter balanced by government subsidy are important policy issues. Therefore, there is a need to find out the economic viability of drip investment in cotton cultivation under different settings. For that purpose, both the Net Present Worth (NPW) and the Benefit-Cost Ratio (BCR) are estimated using the discounted cash flow technique.

The required capital investment is one of the critical factors, which determines the economic viability of the drip irrigation in any crop. Therefore, a brief discussion about the requirement of capital for drip irrigation is done before getting into the aspects of economic viability of the system. Depending upon the nature of crop, the capital investment required for DIM varies. While narrow spaced crops need higher fixed investment, wide spaced crops require relatively low fixed investment. This is because of relatively less requirement of tube length, emitters and drippers. States like Maharashtra are providing nearly 50% of the capital cost as subsidy through a sponsored scheme to encourage the adoption of drip irrigation for different crops. The capital cost of drip set comes to Rs. 21375/acre for the case study farmer without subsidy, and it goes down to Rs. 10631/ acre with 50% subsidy.

Let us now analyse benefit-cost pattern of drip investment using discounted cash flow technique. We have computed both the NPW and the BCR separately by including subsidy and by excluding subsidy in the total fixed capital cost of drip set. Financial viability analysis under different rates of discount would indicate the efficacy of investment at different opportunity costs of investment. Although the BCR is sensitive to discount rate and the degree of such sensitivity depends on the pattern of cash flows, it is interesting to observe the sensitivity of the BCR when there is simultaneous change in both subsidy and discount factor. Therefore, we have attempted to find out answers specifically to the following four important issues namely (1) Whether investment in drip system for cotton cultivation is economically viable to farmers? (2) Can farmers meet the expense of investment in drip irrigation to cultivate cotton without subsidy? (3) To what extent do NPW and BCR change, when the assumed longevity of the drip system is increased from 5 years to 10 years and further to 15 years? and (4) What is the pay back period of drip investment, assuming the current cost and price of the equipment?

Table 5: NPW and B-C ratio of drip irrigated cotton under different scenarios

Subsidy category	Life period assumed	Discount rate	NPW (Rs/acre)	BCR
With subsidy	5 years	15%	60280	1.868
		10%	68965	1.888
	10 years	15%	94894	1.956
		10%	117852	1.983
	15 years	15%	112104	1.982
		10%	148207	2.015

Subsidy category	Life period assumed	Discount rate	NPW (Rs/acre)	BCR
Without subsidy	5 years	15%	51035	1.649
		10%	59301	1.679
	10 years	15%	85650	1.789
		10%	108187	1.835
	15 years	15%	102859	1.834
		10%	138542	1.889

Source: Case study data
Note: Computed using discounted cash flow technique.

The results of net present worth and the benefit-cost ratio estimated, assuming different discount rates and with varying life periods of the system are presented in Table 5. Both the NPW and BCR computed under different scenarios show that the drip investment in cotton cultivation is economically viable for farmers. As expected, the NPW of the investment with subsidy is marginally higher than that under 'no subsidy' option under all scenarios used for analysis. For instance, the NPW at 10% discount rate computed assuming 10 years as life period of the system, increases from Rs.108187/acre without subsidy to Rs. 117852/acre with subsidy. This means that the subsidy enables the farmers to get an additional benefit of Rs. 9665/acre. Similar trend is observed when the NPW is computed assuming 5 and 15 years as life period of the system.

The BCR computed with different discount rates clearly suggests that drip investment is economically viable for cotton farmers under all scenarios. The minimum BCR is 1.649 and maximum is 1.889 when one estimates the same without considering subsidy. The same increases from 1.868 to 2.015 when subsidy is included. The relatively higher BCR realised with subsidy indicates the vital role of subsidy in enhancing the economic viability of drip irrigation. The minimum BCR of 1.649 without subsidy highlights the fact that the investment in drip irrigation in cotton cultivation is economically viable even in the absence of subsidy.[12]

The NPW and BCR are also sensitive to the endurance period of the drip system assumed for calculation. The BCR is expected to be relatively less when one estimates the same assuming relatively less number of survival years as compared to the longer period because of higher density of the capital investment. Though the ideal life period of the drip system for cotton cultivation is 10 years, the experiences of the farmers suggest that the system may work up to 15 years with proper maintenance.[13] In the worst case situation, the system may be expected to work only upto 5 years. We have attempted to see to what extent the NPW and BCR are sensitive to varying life period of the drip system. Table 5 shows that the values of BCR and NPW increase significantly when one estimates them assuming 15 years as life period, as compared to 10 and 5 years period. Interestingly, when we estimate the BCR treating 15 years as life period of the system with 10% discount rate, the value is as high as 2.015. This is expected because the density of capital is thinly distributed between the years when one considers relatively longer life period for computing the BCR.

How many years are needed for the farmer to fully recover the capital investment in drip adoption is an important issue in the context of DIM adoption in cotton cultivation? The year-wise NPW estimated under various scenarios (different discount rates along with different life period of the system) indicates that farmers may be able to recover the entire capital cost of the drip set from the income of the very first year itself when 50% subsidy is availed. However, the farmers will just be short of about Rs. 500/acre to completely recover the whole capital cost of drip system in the very first year when 50% subsidy is not granted for cotton cultivation.

In the context of cotton cultivation under drip method of irrigation, the system is assumed to be used only for one season (for about six months) in a year. In this aspect, it differs from the annual crops like grapes and banana where the system is under use throughout the year. Farmers also report that the system used for cotton cultivation can also be used for cultivating vegetable, pulse and oilseed crops after finishing the cultivation of cotton crop.[14] The gross income generated due to drip system would be enhanced, if income from others crops is included for calculation. As we have not considered income generated from the other crops, private benefit-cost analysis taking into account those benefits would increase substantially.

8. CONCLUDING REMARKS

The present study shows that cultivating cotton under drip method of irrigation provides a number of benefits to farmers over FIM. While reducing the cost of irrigation to the tune of about 50%, drip method of irrigation also helps reducing the cost on weeding, interculture and well preparatory works. Water saving due to the adoption of drip method of irrigation in cotton cultivation is estimated to be about 45% more. Reduced withdrawal of water under DIM also helps to reduce the consumption of electricity to the tune of about 140 Kwh/acre over the conventional irrigation method. The productivity difference between drip irrigated cotton (18.25 qtl/acre) and flood irrigated cotton (8.50 qtl/acre) comes to about 9.75 qtl/acre, which is about 114% higher than the same harvested using flood method of irrigation. Increased productivity with reduced consumption of water under DIM has increased water and electricity productivity substantially. The profit (farm business income) of the cotton crop cultivated using DIM is also higher by about Rs. 20601/acre than that realised from FIM. The net present worth and benefit-cost ratio estimated using discounted cash flow technique shows that the drip investment in cotton cultivation is economically viable under both ‘with’ and ‘without’ subsidy conditions. The analysis also shows that the farmers would be able to repay the whole capital cost of drip system from the crop’s income of the very first year.

The results of the study suggest that cultivation of cotton crop under drip method of irrigation would greatly benefit the farmers. Farmers in Maharashtra and elsewhere in India are unable to increase the productivity of cotton mostly because of inadequate water supply necessary for flood method of irrigation. Most of the times farmers are unable to recover even the cost of cotton cultivation due to poor yield under FIM. Our study also confirms that farmers cultivating cotton using flood method of irrigation are barely able to recover the cost of cultivation because of low productivity. They are thus unable to repay their institutional or non-institutional loans, and in many cases commit suicide. Therefore, promoting drip method of irrigation could possibly reduce the distress of the cotton-growing farmers in Maharashtra as well as in other parts of India. Both the Central and State governments are currently working on implementing various special programmes to improve the agricultural sector in Vidharbha region. While planning such programmes, the governments can allocate a portion of these funds to promote cotton cultivation under DIM.

Though cultivation of cotton under DIM has been picking up in Maharashtra and Gujarat, most farmers in other parts of India are yet to know that cotton cultivation under drip method is economically viable even in the absence of government subsidy. In various parts of the country, severe water scarcity and interrupted power supply are increasingly becoming common. Farmers are able to increase the productivity of cotton significantly under drip irrigation even with these constraints. Farmers are also able to expand the irrigated area with the same amount of water utilized for flood method of irrigation by the adoption of drip method of irrigation. Therefore, the benefits of cultivating cotton under DIM needs to be propagated through quality extension network and special programmes broadcast on a continuous basis through electronic media.

Is there any justification in continuing with the subsidy for drip method of irrigation if it is economically viable even without subsidy? Our study confirms that investment in drip system is economically viable even without subsidy. Nevertheless the case-study farmers were not in favour of immediate scaling down of subsidy mainly for two reasons. First, subsidy gives enormous incentive to the small and marginal farmers to adopt this technology without any hesitation. Second, any reduction in subsidy may hamper the adoption rate which is now only in the initial stage. The enormous subsidy burden on the exchequer can also be justified since drip irrigation saves enormous amount of water and electricity, both of which are becoming increasingly scarce in India. If more accurate estimates of the benefits from the saving of water and electricity in monetary terms for the whole life of the drip system are made, the benefits would be much larger than the cost of subsidy to the government. Therefore, this subsidy should be treated as a reward to motivate the farmers for saving these

2 scarce resources. The debate on whether or not to give subsidy to farmers would continue because of various socio-political reasons. Nonetheless, cultivating cotton under DIM is certainly a "win-win opportunity" for both the individual farmers and for society as a whole.

Notes:

1. CWC (2005) estimate shows that demand for water for other sectors is likely to grow much faster than that of the agricultural sector. As per the estimate, while the demand for water in industry and domestic sector would increase about 7.80 times and 2.40 times respectively between 2000 and 2050, the same would increase only about 1.98 times in agricultural sector. The increased demand for water from other sectors is expected to reduce the availability of irrigation water in the future. More discussion on this issue can be seen from Saleth, (1996); Vaidyanathan (1998) and MOWR, (1999).

2. Drip method of irrigation is one of the methods of micro-irrigation, which was initially introduced in the early seventies by the agricultural universities and other research institutions in India with the aim to increase the water use efficiency in crop cultivation. The development of drip irrigation in terms of area coverage was very slow in the initial years, but significant development has been achieved, especially since 1990s. Due to various promotional schemes introduced by the government of India and states like Maharashtra, area under drip method of irrigation has increased from 1500 ha in 1985 to 70589 ha in 1991-92 and further to 246000 ha in 1997-98 (INCID, 1994; AFC, 1998; GoI, 2004). As of 2005-06, the area under DMI is estimated to have been increased to about 6.25 lac ha (www.indiastate.org).

3. Though cotton is one of the important commercial crops of the country and it can be cultivated under drip method of irrigation, there is a vacuum in the literature on this subject. To our knowledge, no study has been published on the economics of cotton cultivation under drip method of irrigation, especially in India's premier journals like Indian Journal of Agricultural Economics and Economic and Political Weekly.

4. Unlike major foodgrain crops, the productivity of cotton has not increased appreciably since the introduction of green revolution in India. Between 1980-81 and 2000-01, its productivity increased only from 152 kg/ha to 190 kg/ha. This is very low when compared to the productivity of cotton in countries like USA, China, etc. Predominant cultivation of cotton under rainfed condition in India is considered to be the important reason for this.

5. A crucial reason for carrying out these case studies is that it allows the researcher to clearly understand every aspect of cotton cultivation under drip method of irrigation. This may not always be possible in a sample survey. Whether the results arrived from a case study is sufficient enough to make a solid policy decision is a major question that has been debated by the economists over the years.

6. These farmers are selected from three different villages namely Shingola, Nari and Palaskheda, all of which are located in Jamner taluka of Jalgaon district.

7. This cost is A2+FL. By the definition of Commission for Agricultural Costs and Prices (CACP), cost A2+FL includes all actual expenses in cash and kind incurred in production by the farmer plus rent paid for leased-in land as well as imputed value of family labour. The CACP uses nine cost concepts for cost calculation, the definition of which is available in CACP (2005).

8. Irrigation cost includes both human labour cost used for irrigation purpose and the electricity cost. Since farmers in Maharashtra State pay the electricity tariff on flat-rate basis, it is difficult to get the actual unit cost of electricity. Therefore, we have estimated the electricity cost of irrigation using the average unit cost of power supply, which prevailed in the State during the year 2006-07 (Rs. 3.30/kwh) and multiplying it by the hours of irrigation of the cotton crop.

9. Alternatively, one can also estimate water volume applied by multiplying average discharge of the pumpset by number of pump operating hours. However, since it requires a device to measure the discharge of each pumpset that is also expected to change depending upon the water level of the well, we have not followed this method in estimating the water consumption.

10. Analogous to the findings of our study, data from the CACP also suggests that the income from cotton cultivation is tending to be very low because of increased cost of cultivation and low productivity. For instance, in Maharashtra State, the ratio of value of output from cotton crop to cost C2 has declined from 1.195 in 1975-76 to 0.799 in 2001-02, indicating that farmers are unable to meet even the cost of cultivation from the crop's income. More discussion on this issue can be seen from Narayanamoorthy (2006 and 2007).

11. This profit is the difference between gross value of production from cotton and cost A2+FL, and should ideally be called as farm business income.

12. Results of this study are also in conformity with some of the earlier studies carried out on three crops namely grapes, banana and sugarcane utilising field survey data from Maharashtra (see, Narayanamoorthy, 1997; 2003 and 2004).

13. There is no ideal life period of drip system. For instance, Dr. S. N. Kulkarni of ICID, an expert in micro-irrigation, argues that the drip set designed for cotton crop can seldom work for 15 years under field condition. This view does not coincide with the argument of the leading manufacturers of drip set and also with the perceptions of farmers adopting drip system for cotton crop.

14. One may tend to argue that the drip system designed for cotton crop may not be suitable for cultivating other crops because of variations in spacing followed for cultivating the stated crops. However, the farmers seem to be able to adjust the spacing of these crops keeping in view the drip set designed for cotton.

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