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# An assessment of the economic impact of drip irrigation in vegetable production in India

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**Abstract** Several studies have assessed the technical and economic feasibility of drip irrigation in a number of crops and have proven its potential to save water and energy, and to increase crop yields. However, only a few studies have assessed its techno-economic potential in vegetable crops. In this paper, using survey data from Indian state of Tamil Nadu, we assess its potential in brinjal, a widely cultivated and consumed vegetable in the country. The findings indicate that besides savings in water (40%) and electricity (629 kwh/acre), the drip irrigation reduces use of other inputs, e.g. fertilizers (31%), and enhances crop yield by 52%. On the whole, its application in brinjal results in 54% higher net returns over the conventional method of irrigation. Benefit-cost ratio in drip irrigation is quite attractive making it a viable option for sustainable management of irrigation water.

**Keywords** Drip irrigation, Water scarcity, Economic benefits

**JEL classification** Q15, Q16, Q18, Q25

## 1 Introduction

Several studies on the application of drip method of irrigation (DMI) in high-value crops (e.g., grapes, banana, sugarcane and cotton) provide strong evidence of its techno-economic feasibility (INCID 1994; AFC 1998; Narayanamoorthy 1997, 2004a; Namara et al. 2005). But, there is hardly any study that provides such an evidence on its application in vegetable crops. The main aim of this paper is to assess economic impact of the application of drip method of irrigation in vegetable cultivation focussing on brinjal, a widely grown and consumed crop in south Asia.

In India, brinjal is grown on 0.72 million hectares, equalling 10% of the total area under vegetable crops (NHB 2014), next only to China. Its yield, however, is low (18.6 t/ha), just half of that in China. One of the main reasons for low yield is inadequate and erratic supply of irrigation water. Vegetables are fleshy and sensitive to water stress, and therefore require irrigation at regular intervals and at their critical growth stages (Chauhan, et al. 2013). The water stress may delay maturity of the crop and result in poor quality and low yield as well. However, owing to acute water scarcity (see, MOWR 1999; Seckler et al. 1999; CWC 2010; Amarasinghe and Smakhtin 2014), farmers are unable to provide irrigation at a regular interval for crops.

The drip method of irrigation has the potential to completely eliminate water stress for crops even under severe water scarcity conditions. Through a network of pipes and emitters, the water is delivered directly in the root zone. This method is entirely different from the conventional method, where water is supplied to the whole crop land. The excess supply of water through conventional method is a potential loss of water, and at times may adversely affect crop yield, quantitatively as well as qualitatively. The evidence

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based on experiment and field studies (e.g. INCID 1994) show that with DMI, water use efficiency can be achieved up to 100 % as against 35-40% with flood method of irrigation (FMI). DMI also enhances crop yields without any additional cost (Shreshtha and Gopalakrishnan 1993; Narayanamoorthy 1997, 2004, 2005; Dhawan 2002; Postal 2001; Namara et al. 2005; Shah & Keller 2014). This is confirmed by the evidence from some field surveys (AFC 1998; Narayanamoorthy 1997, 2004a).

The evidence on the benefits of DMI in vegetable cultivation, especially brinjal is scarce. Some experimental studies show that DMI in brinjal increases crop yield in the range of 20 to 60% besides saving water by 40 to 60% (Singh & Maurya 1992; Biswas 2010; Chauhan et al. 2013). The evidence from controlled experimentations although prove the technical feasibility of DMI, but not its economic feasibility in farmers' conditions as the establishment of DMI requires fixed capital investment that needs to be factored while assessing costs and benefits associated with it.

With this background, using data collected from sample farmers, in this paper we assess resource use efficiency under drip versus conventional method of irrigation in brinjal. Specifically, we generate operation-specific estimates of savings in costs and improvement in crop yield and the associated net returns. Further, using these parameters, we assess economic viability of DMI to provide feedback to policymakers for informed decisions for financial support to DMI.

## 2 Data and method

### 2.1 Data

The study is based on data collected from a sample of farmers cultivating brinjal with drip and flood methods of irrigation in Sivagangai district of Indian state of Tamil Nadu. This district is located in the southern-eastern part of the state, and was purposively selected because of acute water scarcity there. The agriculture in the district is rain-dependent with tank irrigation as one of the main sources of irrigation. The normal rainfall in the district is 873mm, but annual rainfall fluctuates widely, the coefficient of variation being 17.33% during 2001 to 2014. Since, water availability in tanks is associated with rainfall, irrigation is not assured (GoTN 2014). In order to make effective use of scarce water from borewell and well, farmers have been using drip method of irrigation in several crops like sugarcane, banana, chilli and brinjal.

Brinjal is an important crop in the district occupying 37% of the total vegetable crops area. Though, the crop is cultivated in different parts of the district, it is more prominent in Kaliyarkovil block because the soil is more suitable for its cultivation there. Farmers have traditionally been cultivating brinjal in this block using FMI. But, in recent years, because of declining water table in the wells they have started switching over to DMI.

For this study, we have selected a total of 50 brinjal farmers; 25 adopters of DMI and 25 non-adopters of DMI. The adopters were selected randomly from the list obtained from the State Department of Agriculture. The non-adopters were selected purposively; only those farmers were selected whose fields were nearer to the fields of adopters of DMI. The relevant data were collected from the sample farmers for 2012-13.

### 2.2 Analytical method

To compare technical and financial parameters associated with brinjal cultivation with and without DMI, we use partial budgeting technique. Since drip irrigation involves capital investment, we assess its economic viability estimating net present worth (NPW) and benefit-cost ratio (BCR) following discounted cash flow technique (Gittinger 1984). The NPW is the difference between the sum of the present value of benefits and the costs accrued during the life period of the drip set. Mathematically, the NPW and BCR can be expressed as:

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

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

where, $B_t$ is the benefit in year t, $C_t$ is the cost in year t; t = 1, 2, 3,…….n; and i is the discount rate or the opportunity cost of the investment.

**Table 1. Water and electricity consumption in drip and flood irrigated brinjal**

| Particulars | DMI | FMI | Change over FMI | |
|---|---|---|---|---|
| | | | Absolute | Percent |
| Pumpset HP | 5.40 | 5.26 | — | — |
| Number of irrigation/acre | 226.20 | 72.44 | 153.76 | 212.26 |
| Hours required per irrigation/acre | 1.02 | 5.47 | -4.45 | -81.35 |
| HP hours of water used/acre | 1245.91 | 2084.26 | -838.35 | -40.22 |
| Electricity consumption (kWh/acre) | 934.43 | 1563.19 | -628.76 | -40.22 |

Source: Field survey.

As per NPW criterion, the DMI is economically viable if the present value of benefits is greater than the present value of costs. BCR is closely related to NPW. If the value of BCR is greater than unity, the investment can be considered economically viable. From cross-sectional data, it is not possible to determine the actual cash flows for the entire life span of drip set. Therefore, we estimate cash inflows and cash outflows on the following assumptions.

- The life period of the drip-set is five years (INCID, 1994). But, based on the experience of adopters of DMI a drip set can last up to 10 years, hence we also estimate these assuming 10 years life span.
- The operational cost and income from brinjal remain constant in real terms during the life period of drip set. So are the technologies and cultivation practices.
- The discount rate or the opportunity cost of capital is assumed to be 10% and 15%.

## 3 Economics of brinjal cultivation under DMI versus FMI

### 3.1 Water and electricity consumption

Since DMI delivers water directly in the root zone, it saves substantial amount of water being lost in conveyance, distribution and application as in the case of FMI. Under field conditions, it is difficult to arrive at precise estimates of water used for irrigation because of variation in the horse power (HP) of the pumpsets used to lift water, groundwater depth, capacity and quality of water delivery pipes, conveyance distance, field terrain, etc. We, therefore, compute quantum of water in terms of horse power hours, multiplying HP of the pump-set by the number of hours used to pump water.

Table 1 compares water use in DMI versus FMI. Though the numbers of irrigations are much larger with DMI, the duration of hours used for each irrigation is much less; 1.02 hours/acre compared to 5.47 hours/acre with FMI. As a result, the total water used for drip-irrigated crop is 1245 HP hours/acre as against 2084 HP hours/acre in FMI. In other words, drip irrigation saves about 40% of the water.

Less use of water means less consumption of electricity to pump out the water from wells. Following Shah (1993), we have estimated electricity consumption assuming that a pumpset of one HP requires 0.750 kWh of energy per hour. Accordingly, the electricity consumption with DMI is estimated 934 kWh/acre as against 1563 kWh/acre with FMI, saving of about 41%.

### 3.2 Cost of cultivation

Water saving and higher crop yields are often highlighted as the two major advantages of drip method of irrigation. But, DMI also reduces cost of cultivation, which is not much documented in the empirical literature. DMI reduces the cost associated with operations like irrigation, weeding, ploughing and preparatory works. To study the impact of DMI on various operational costs of cultivation, we have compared cost associated with these operations under drip-irrigated brinjal with flood-irrigated brinjal.

Table 2 compares operation-wise cost of cultivation under DMI and FMI systems. As expected, DMI saves

**Table 2. Operation-wise cost of cultivation of drip and flood irrigated brinjal**

(Rs/acre)

| Operation | DMI | FMI | Change over FMI | |
|---|---|---|---|---|
| | | | Absolute | Percent |
| 1. Preparatory works | 2940 | 4580 | -1640 | -35.80 |
| 2. Seed and sowing | 860 | 892 | -32 | -3.60 |
| 3. Fertilisers | 10361 | 15074 | -4714 | -31.30 |
| 4. Farm yard manures (FYM) | 2516 | 2870 | -354 | 12.30 |
| 5. Pesticides | 13531 | 13935 | -404 | -2.90 |
| 6. Weeding and interculture | 2760 | 10744 | -7984 | -74.30 |
| 7. Irrigation | 2400 | 6416 | -4016 | -62.60 |
| 8. Harvesting | 13848 | 10720 | 3128 | 29.20 |
| 9. Transport and marketing | 8800 | 8403 | 397 | 4.70 |
| 10. Others | 1902 | 2006.00 | -104 | -5.20 |
| Total cost | 59918 | 75642 | -15723 | -20.80 |

Note: The cost of cultivation referred in this paper is cost A2+FL as per CACP definition.
Source: Field survey.

considerable cost of irrigation (>60%).[1] Since DMI supplies water directly to the root zone that does not allow weeds to grow, there are huge savings in the costs towards weeding and inter-culture (74%). Likewise, relatively fewer requirements of ploughing and other preparatory operations reduce cost of field preparation. On the whole, DMI reduces total cost of cultivation by 20%[2].

### 3.3 Crop yield

Table 3 clearly shows that yield of brinjal cultivated with DMI (184.74 qtl/acre) is 1.5 times more over that obtained with FMI. Farmers have reported four main reasons for higher yield with DMI. First, by supplying right quantity of water at right time, DMI reduces moisture stress for the crop leading to better plant growth and canopies and thereby better flowering and less pre-mature dropping of flowers and fruits. Second, by restricting supply of water to root zone, DMI avoids water flow to other zones and hence less infestation of weeds. Third, supply of water at regular intervals allows the crop to absorb plant nutrients avoiding their loss through leaching and evaporation. Fourth, better plant growth allows extendable harvest of fruits. Besides higher yield, DMI enhances productivity of water as well as of energy, which are reported in table 3.

### 3.4 Profits

The evidence on the reduction in cost and yield advantage clearly establishes that DMI is technically and economically superior over FMI. Table 4 presents gross and net returns from brinjal cultivation. Gross returns are obtained multiplying yield with the prices realized by the framers. And, the net returns are estimated deducting the variable cost of cultivation from gross returns. The net returns are estimated Rs. 2,43,516 per acre of brinjal with DMI as compared to Rs. 1,58,654 with FMI.[3] In other words, the brinjal cultivation using drip irrigation generates 54% more of profit over the conventional method of irrigation.

[1] For irrigating crops, all the sample farmers in both DMI and FMI categories have used only electrically operated pump set which requires no or very less operating expenditure. In this study, irrigation cost includes only the human labour cost that are used for managing water supply to crops as electricity has been supplied free of cost to all farmers in Tamil Nadu over the last almost three decades.

[2] 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 has been using nine cost concepts for cost calculation, the definition of which can be seen from CACP (2005).

[3] This profit is the difference between gross value of production from brinjal crop and cost A2+FL. This should ideally be called as farm business income.

**Table 3. Crop yield and resource productivity**

| Particulars | DMI | FMI | Change over FMI | |
|---|---|---|---|---|
| | | | Absolute | Percent |
| Crop yield (qtl/acre) | 184.74 | 120.77 | 63.97 | 52.97 |
| Cost of production (Rs/qtl) | 324.34 | 626.33 | -301.99 | -48.22 |
| Water productivity (kg/HP hour of water) | 14.83 | 5.79 | 9.03 | 155.90 |
| Electricity productivity (kg/kWh) | 19.77 | 7.73 | 12.04 | 155.90 |

Source: Field survey.

**Table 4. Profit from brinjal cultivation with and without DMI**

(Rs/acre)

| Particulars | DMI | FMI | Change over FMI | |
|---|---|---|---|---|
| | | | Absolute | % |
| 1. Gross cost of cultivation | 59918 | 75642 | -15723 | -20.79 |
| 2. Gross value of production | 303435 | 234295 | 69139 | 29.51 |
| 3. Profit (farm business income) | 243517 | 158654 | 84863 | 53.49 |
| 4. Capital cost of DMI (without subsidy) | 36928 | — | — | — |
| 5. Subsidy for DMI | 19136 | — | — | — |
| 6. Capital cost of DMI (with subsidy) | 17792 | — | — | — |

Note: Cost of cultivation used in this study refers to cost A2 +FL.
Source: Field survey.

An interesting observation is that using such large profits from a single crop, farmers can meet the capital cost of drip system which is Rs. 36,928/acre.

### 3.5 Economic viability of investment in drip irrigation

Although, farm business income from cultivation of brinjal using DMI is significantly higher as compared to conventional irrigation method, this cannot be treated as the effective (real) profit as we have not accounted for the cost, depreciation and interest on capital investment associated with installation of drip system. Importantly, the longevity of drip system is an important factor in estimation of net present value. DMI is capital-intensive technique. Therefore, it is imperative to assess the economic viability of investment in drip irrigation. The average capital cost of drip set is estimated Rs. 36,928/acre without subsidy (table 4). Most states including Tamil Nadu are providing almost 50% of the capital cost as subsidy either through a state sponsored scheme or centrally sponsored scheme to encourage the adoption of drip irrigation in different crops.

The NPW and the BCR have been estimated with and without subsidy using different discount rates. Table 5 presents the results. As expected, the NPW with subsidy is marginally higher than without subsidy. For example, the NPW at 10% discount rate for a drip set with five years life is Rs. 8,89,548/acre without subsidy and Rs. 9,06,945/acre with subsidy. The benefit cost ratio is quite attractive; 4.36 to 4.64 without subsidy, and marginally higher with subsidy.

NPW and BCR are sensitive to the life of drip system. The ideal life of a drip system is 5 years, but may go up to 10 years if maintained properly. The results presented in table 5 show that with increase in life of drip set the NPW increases significantly but with marginal increase in BCR.

Vegetable prices are volatile. Prices often decline with increase in their arrival in the market. Brinjal is no exception. Thus, we analyse sensitivity of NPW and BCR to price changes. On the assumption that price of brinjal falls to Rs. 10/kg from Rs15-20/kg, the NPW and BCR decline considerably (table 6). Yet the investment in drip remains attractive. In the context of

**Table 5. NPW and BCR for drip irrigated brinjal**

| Subsidy category | Life (years) | Discount rate (%) | NPW (Rs. in '000/acre) | BCR |
|---|---|---|---|---|
| With subsidy | 5 | 15 | 801 | 4.70 |
| | | 10 | 907 | 4.72 |
| | 10 | 15 | 1207 | 4.82 |
| | | 10 | 1480 | 4.85 |
| Without subsidy | 5 | 15 | 784 | 4.36 |
| | | 10 | 890 | 4.41 |
| | 10 | 15 | 1190 | 4.58 |
| | | 10 | 1463 | 4.64 |

Source: Estimated by authors using field survey data.

**Table 6. Sensitivity of NPW and BCR to price changes**

| Subsidy category | Life (years) | Discount rate (%) | NPW (Rs. in '000/acre) | BCR |
|---|---|---|---|---|
| With subsidy | 5 | 15 | 403 | 2.86 |
| | | 10 | 457 | 2.87 |
| | 10 | 15 | 611 | 2.93 |
| | | 10 | 751 | 2.95 |
| Without subsidy | 5 | 15 | 386 | 2.65 |
| | | 10 | 440 | 2.68 |
| | 10 | 15 | 594 | 2.79 |
| | | 10 | 733 | 2.83 |

Source: Same as for table 5.

investment in DMI, it is also important to estimate the payback period. The results presented in table 6 clearly indicate that investment is fully recovered in the first year of the project.

## 4 Conclusions

The study clearly suggests that DMI can be a viable option in achieving the mission of 'more crop per drop' envisaged by the government. Owing to various reasons and competition among different sectors, the water availability for irrigation is going to be reduced considerably in future that will pose serious threat to sustainability of agriculture. The study proves that DMI is economically viable and environmentally sound alternative of conventional method of flood irrigation. Although, evidence shows that drip investment is economically viable, the initial investment required for installing DMI is beyond the reach of small farmers. This calls for improving small farmers reach to financial institutions.

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