AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 08 (August, 2026)
Available online at http://www.agrimagazine.in

From Every Drop to More Crop: Economic Importance of Micro-Irrigation in Rajasthan

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"Saving Water, Increasing Productivity and Strengthening Farm Income"

Introduction

Water is one of the most critical inputs in Indian agriculture, and its importance becomes even greater in Rajasthan, where agriculture is frequently constrained by low and erratic rainfall, high temperatures, sandy soils and increasing pressure on groundwater resources. In such a situation, improving the productivity of every unit of irrigation water is essential for sustaining agricultural production and farmer income. Traditional surface or flood irrigation often involves applying large quantities of water over the field. A significant proportion may be lost through evaporation, runoff and deep percolation. Micro-irrigation, mainly comprising drip and sprinkler irrigation, offers an alternative by delivering water more precisely and efficiently. The concept is closely associated with the principle of "Per Drop More Crop", under which the Government of India promotes efficient farm-level water use through micro-irrigation. As of 2025, the Per Drop More Crop programme had covered about 96.97 lakh hectares nationally, including 46.37 lakh hectares under drip and 50.60 lakh hectares under sprinkler irrigation.

What is Micro-Irrigation?

Micro-irrigation is a method of applying irrigation water in a controlled and efficient manner according to crop requirements.

The two major systems are:

Drip Irrigation

In drip irrigation, water is delivered slowly and directly to the root zone through emitters fitted to lateral pipes.

Major advantages include: Reduced water losses, Precise application of water, Better moisture management, Possibility of fertigation, Reduced weed growth between crop rows, Improved water and nutrient-use efficiency, Potential reduction in irrigation-related labour.

Sprinkler Irrigation

Sprinkler irrigation distributes water through pipes and nozzles under pressure, producing droplets similar to rainfall. It is particularly useful for many field crops and in areas where soil and topographic conditions make surface irrigation less efficient.

Why Micro-Irrigation is Important for Rajasthan

Rajasthan has diverse agro-climatic conditions, but large areas experience water scarcity and high evaporative demand. Therefore, the objective should not simply be to increase the quantity of irrigation water used, but to increase the productivity obtained from each unit of

water. The Government of Rajasthan has specifically identified drip and sprinkler irrigation as efficient water-management practices for improving crop yield and quality while saving water. According to the Rajasthan Government's 2024–25 progress report, up to December 2024, approximately: 34,469 hectares had been brought under drip and mini-sprinkler irrigation. 56,727 hectares had been brought under sprinkler irrigation. The state had also made a provision of ₹438.35 crore under the micro-irrigation component for 2024–25, along with additional state funding for micro-irrigation and the Micro-Irrigation Fund.

Water Saving: The First Economic Benefit: The most direct advantage of micro-irrigation is efficient water use. The Rajasthan Department of Agriculture states that drip irrigation can achieve substantial water savings through efficient application, while sprinkler irrigation is promoted for improved water-use efficiency. A recent three-year field experiment on cumin at the ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan, demonstrated the potential of drip fertigation under arid conditions. The study found that drip fertigation reduced seasonal water use by approximately: 58.2% at 0.4 IW/CPE, 38.8% at 0.6 IW/CPE, and 19.7% at 0.8 IW/CPE, compared with surface irrigation. This is particularly important in Rajasthan, where water saved from one crop can potentially support additional cultivated area or reduce pressure on groundwater resources.

Higher Crop Productivity: Water saving becomes economically meaningful when it is accompanied by stable or increased crop productivity. The recent cumin study in arid Rajasthan provides a strong example. Under drip irrigation at 0.8 IW/CPE with 100% recommended dose of fertilizer, cumin seed yield reached 830.83 kg/ha, compared with 400.80 kg/ha under the surface-irrigated control. This represents a substantial improvement in productivity under the experimental conditions. The improvement can be attributed to the more precise supply of water and nutrients to the crop root zone, helping maintain favourable soil-moisture conditions during crop growth.

Economic Returns from Drip Fertigation: The most important question for a farmer is not simply: "How much water is saved?" but: **"**How much additional income is generated from the saved water?" The Ajmer cumin experiment demonstrated a positive economic response to drip fertigation. Under the best performing treatment drip irrigation at 0.8 IW/CPE with 100% RDF—the study reported:

Economic Indicator	Result
Seed yield	830.83 kg/ha
Gross return	₹1,41,229/ha
Net return	₹89,559/ha
Benefit-Cost ratio	1.73
Essential oil content	4.54%
Maximum reported WUE	2.46 kg/ha/mm

These results demonstrate that efficient irrigation can simultaneously improve water productivity and economic productivity.

Micro-Irrigation and Fertigation: One of the important advantages of drip irrigation is that fertilizers can be supplied through irrigation water. This technique is known as fertigation. Instead of applying nutrients uniformly over the entire field, fertigation can deliver nutrients closer to the crop root zone. Economic advantages of fertigation include: Better targeting of fertilizer application, Potential reduction in nutrient losses, Improved nutrient-use efficiency, Reduced labour requirement for repeated fertilizer application, Better synchronization of nutrient supply with crop demand, Potential improvement in crop quality and yield. The Ajmer cumin study reported improved yield, water-use efficiency and economic returns under drip fertigation compared with surface irrigation.

Micro-Irrigation and Water Productivity: A useful economic indicator for Rajasthan is water productivity, which broadly measures how much agricultural output or economic return is generated from a unit of water. Traditional irrigation often focuses on the amount of water supplied.

Micro-irrigation changes the question to:
"How much crop and income can be produced from one unit of water?"
This shift from water consumption to water productivity is particularly important for water-scarce regions. In the Ajmer cumin experiment, drip fertigation substantially improved water-use efficiency, with the highest pooled value reported under 0.8 IW/CPE + 100% RDF at 2.46 kg/ha/mm.
Micro-Irrigation and Farmer Income: The economic benefits of micro-irrigation can arise through several channels:
A. Higher yield; Better moisture management can improve crop growth and productivity.
B. Water saving**;** Lower irrigation requirements can reduce pumping and irrigation-related costs where water is pumped.
C. Better fertilizer use; Fertigation can improve the efficiency of nutrient application.
D. Labour saving; Automation and controlled irrigation can reduce some labour requirements.
E. Crop diversification; Efficient irrigation can make cultivation of horticultural and high-value crops more feasible in suitable locations.
F. Risk reduction; Better control over irrigation can reduce the risk of crop stress during critical growth stages. Therefore, micro-irrigation can contribute to increasing net returns rather than merely increasing gross production.

Government Support in Rajasthan

Government support is important because the initial installation cost of drip and sprinkler systems can be a major barrier, particularly for small and marginal farmers. Under the Per Drop More Crop (PDMC) scheme, financial assistance is provided for installation of micro-irrigation systems. At the national level, the assistance has been reported at 55% of unit cost for small and marginal farmers and 45% for other farmers. Rajasthan has provided additional support through its state programme. The state's 2024–25 report stated that: General farmers were eligible for 70% subsidy. Scheduled Caste/Scheduled Tribe, women, small and marginal farmers were eligible for 75% subsidy, subject to scheme conditions. The state had also made substantial budgetary provisions for micro-irrigation during 2024–25.

Micro-Irrigation and Small & Marginal Farmers

Small and marginal farmers face a particular challenge because the initial cost of installing drip or sprinkler systems may be high relative to their farm size and annual income.
Therefore, subsidy alone should not be the only strategy.
A complete support system should include: Subsidy support, Institutional credit, Technical training, Installation assistance, Maintenance services, Water-quality testing, Irrigation scheduling advice, Crop-specific fertigation recommendations
This approach can make micro-irrigation more economically accessible and sustainable.

Major Challenges in Adoption

Despite its advantages, several factors can restrict adoption.
High Initial Investment**;** The initial installation cost can discourage farmers, particularly those with small landholdings.
Maintenance Requirements; Filters, pipes and emitters require regular inspection and cleaning.
Emitter Clogging; Poor-quality or saline irrigation water can cause clogging and reduce system efficiency.
Technical Knowledge; Farmers need training regarding pressure, irrigation duration, fertigation and maintenance.
Fragmented Landholdings**;** Very small or irregularly shaped fields can make system design more complicated.
Market Risk; If micro-irrigation encourages farmers to shift towards high-value crops, market-price fluctuations can influence profitability.

The recent Rajasthan cumin study also highlighted installation cost, saline water, emitter clogging and maintenance requirements as important constraints to wider adoption.

From "More Crop per Drop" to "More Income per Drop"

The ultimate objective of micro-irrigation should go beyond water saving.

A farmer needs:

More Crop + Less Water + Efficient Inputs + Better Prices = More Farm Income

Role of Smart Agriculture

The next generation of micro-irrigation will increasingly combine irrigation technology with digital agriculture.

A promising model for Rajasthan could be:

Drip/Sprinkler + Solar Pump + Soil Moisture Sensor + Weather Forecast + Fertigation + Mobile Advisory

Such integration can help farmers determine: When to irrigate, How much water to apply, When to apply fertilizer, How weather conditions may affect irrigation demand, Whether irrigation can be postponed after rainfall.

The Government of India has also continued to emphasize precision irrigation and water-saving technologies under PDMC.

Conclusion

For Rajasthan, water is not merely a natural resource it is an economic resource. Every litre of irrigation water has an opportunity cost, particularly in regions where groundwater is limited and rainfall is uncertain. Micro-irrigation provides an important pathway for producing more agricultural output with less water. Drip and sprinkler systems can improve water-use efficiency, support better crop management and, when appropriately designed and managed, improve farm profitability. The experience from Rajasthan's cumin research clearly demonstrates the potential of drip fertigation to increase productivity, save irrigation water and improve economic returns. Government support through the Per Drop More Crop programme and Rajasthan's state-level initiatives can further accelerate adoption. The future of Rajasthan agriculture therefore lies not simply in using more water, but in using every drop more intelligently.

"Every Drop Saved is an Investment in the Next Crop."

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