Society of Krishi Vigyan
www.iskv.in

J Krishi Vigyan 2025, 13(3) : 605-610

DOI: 10.5958/2349-4433.2025.00109.2

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Socio-Economic Profiling of Drip Irrigation Technology Adopters in Cotton Cultivation-A Comparative Study in Three States of India

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ABSTRACT

Cotton, a highly water demanding yet economically significant crop, is particularly well-suited for drip irrigation systems. However, despite the well-documented advantages of drip irrigation, its adoption in cotton cultivation remains modest at around 20 percent. The uptake of this technology is influenced by several factors, with the socio-economic characteristics of farmers playing a crucial role. This gap between proven benefits and limited adoption prompts a key question: which socio-economic and contextual determinants affect the diffusion of drip irrigation technology? Extension research thus plays an essential role in identifying whether socio-economic differences exist among drip irrigation adopters across different states. Accordingly, the present study was conducted to systematically analyze the variations in socio-economic profiles of drip irrigation adopters in three major cotton-growing states of India *i.e.,* Maharashtra, Gujarat, and Tamil Nadu. A structured survey design was used, involving 120 drip-irrigating cotton farmers from each state, making a total sample size of 360 respondents. The research objectives were addressed using well-established methodologies and rigorous analytical approaches. Results indicated that variables such as age, education, and experience in drip irrigation showed no significant differences among farmers across the three states, while factors including cotton farming experience, farm size, and operational area under drip irrigation were found to differ significantly among them. The study's findings are expected to contribute to policy development and guide strategic initiatives to enhance drip irrigation adoption in cotton farming.

Keywords: Adoption, Cotton, Drip irrigation, Gujarat, Maharashtra, Socio-economic profiling,Tamil Nadu.

INTRODUCTION

In India, Maharashtra stands at the forefront of drip irrigation adoption, followed by Andhra Pradesh, Karnataka, and Tamil Nadu. Despite these advancements, the total area under drip irrigation constitutes less than one percent of the country's total irrigated area, highlighting a vast potential for expansion (Kumar and Jitarwal, 2012; Yadav *et al,* 2017). Cotton is one of the world's most important fiber crop and the second most important oil seed crop (Gill and Bhatt, 2015; Sathya *et al,* 2022). India leads in the cultivation of cotton in the world (Vikram Simha *et al,* 2022). It is highly suitable for drip irrigation owing to its long crop duration, compatibility with varied growing environments, potential for early sowing, adaptability to flexible drip systems, higher economic returns, improved fertilizer use efficiency, enhanced seed cotton yield, suitability for light-textured soils, uniform germination and maturity, and superior fibre quality. Several studies have explored the scope, potential, and impact of drip irrigation across various crops. Karpagam *et al* (2010) reported a 24.98% increase in yield efficiency in sugarcane under drip irrigation, along with a 23.58% improvement in income efficiency and a remarkable 40.64% gain in water use efficiency. However, Karpagam *et al* (2011) identified major constraints to adoption, with the high initial investment cost-despite the provision of subsidies-being the most significant (mean score: 73.75), followed by inadequate subsidy levels (mean score: 63.33). Further, a study by Karpagam *et al* (2012) emphasized that social factors such as social structure, networks, and interactions strongly influence the adoption of drip irrigation. Subsequently, Karpagam *et al* (2013) observed that most sugarcane farmers using drip systems exhibited moderate to high levels of social dynamics (90.0%), whereas a majority

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Table 1. Age wise distribution of drip irrigation farmers. (N=360)

Sr. No.	Category	Tamil Nadu		Maharashtra		Gujarat		Total	
		No.	%	No.	%	No.	%	No.	%
1.	Young (Up to 35yrs)	4	3.30	16	13.30	9	7.50	29	8.10
2.	Middle (36-45 yrs)	51	42.50	47	39.20	53	44.20	151	41.90
3.	Old (Above 45 ys)	65	54.20	57	47.50	58	48.30	180	50.00
F Value (Among three groups of drip users) = 0.110 ^{NS}; p=0.896 (p > 0.05) -									

Table 2. Education wise distribution of drip irrigation farmers. (N=360)

Sr. No.	Category	Tamil Nadu		Maharashtra		Gujarat		Total	
		No.	%	No.	%	No.	%	No.	%
1.	Illiterate	1	0.80	3	2.50	4	3.30	8	2.20
2.	Primary School	19	15.80	26	21.70	38	31.70	83	23.10
3.	Middle School	37	30.80	20	16.70	32	26.70	89	24.70
4.	High School	31	25.80	38	31.70	15	12.50	84	23.30
5.	Higher Secondary school	21	17.50	20	16.70	18	15.00	59	16.40
6.	Collegiate	11	9.20	13	10.80	13	10.80	37	10.30
F Value (Among three groups of drip users) = 2.640 ^{NS}; p=0.073 (p > 0.05)									

Table 3. Cotton farming experience wise distribution of drip irrigation farmers. (N=360)

Sr. No.	Category	Tamil Nadu		Maharashtra		Gujarat		Total	
		No.	%	No.	%	No.	%	No.	%
1.	Up to 10 years	30	25.00	22	18.30	11	9.20	63	17.50
2.	10-20 years	33	27.50	17	14.20	17	14.20	67	18.60
3.	More than 20 years	57	47.50	81	67.50	92	76.70	230	63.90
F Value (Among three groups of drip users) = 13.805**; p=0.000 (p < 0.01)									

** Significant at 1 % level

of non-users (62.5%) showed low levels of such dynamics. Although these studies demonstrate the multifaceted benefits and influencing factors of drip irrigation across different crops, there remains limited empirical evidence focusing on cotton. Given the crop's suitability and economic importance, it becomes essential to analyze the socio-economic characteristics of cotton farmers adopting drip irrigation technology to better understand the drivers and constraints shaping its diffusion.

MATERIALS AND METHODS

The present study was carried out across three major cotton-growing states, Maharashtra, Gujarat, and Tamil Nadu. From each state, two districts were selected based on the predominance of cotton cultivation under drip irrigation. Within each chosen district, two villages were identified using the extent of drip-irrigated cotton area as the selection criterion. From every selected village, 30 cotton farmers were randomly chosen, resulting in a total of 120 farmers per state and an overall sample size of 360 respondents. To analyse the socio-economic profile of drip irrigation adopters, key variables such as age, education, farming experience in cotton, experience in drip irrigation, farm size, and area under drip irrigation were considered. The selection of these variables was guided by expert opinions, relevant literature, and their suitability to the study objectives. Data were collected through a structured interview schedule administered in the selected villages. The gathered information was then compiled and subjected to appropriate statistical analysis to derive meaningful and systematic conclusions.

Duncan's Post Hoc test for comparison of differences - Farming Cotton Experience

Sr. No	Treatment Groups	Means for groups (Sub set for alpha= 0.05)	
		1	2
1.	T_1(Tamil Nadu Farmers)	18.2250	
2.	T_2(Maharashtra Farmers)		22.4417
3.	T_3 (Gujarat Farmers)		24.658

Gujarat 24.6583 > **Maharashtra** 22.4417 > **Tamil Nadu** 18.2250

Table 4. Experience in drip irrigation. (N=360)

Sr. No.	Category	Tamil Nadu		Maharashtra		Gujarat		Total	
		No.	%	No.	%	No.	%	No.	%
1.	Less than 2 years	2	1.70	1	0.80	0	0	3	0.80
2.	2-8 years	85	70.80	83	69.20	68	56.70	236	65.60
3.	More than 8 years	33	27.50	36	30.00	52	43.30	121	33.60
F Value (Among three groups of drip users) =0.081^{NS}; p=0.923 (p > 0.05)									

NS - Non-Significant

RESULTS AND DISCUSSION

Socio-economic profile of drip irrigation farmers

Six variables *i.e.,* age, education, farming experience in cotton, experience in drip irrigation, farm size, and area under drip irrigation were considered.

Age wise distribution of drip irrigation farmers

Table 1 shows that, based on age-wise distribution, the drip irrigation farmers from Tamil Nadu, Maharashtra, and Gujarat exhibited no significant differences. Hence, there is not much variation among the three groups in terms of age. Additionally, nearly 50 percent of the farmers fell under the old-age category. The similar view was expressed by Kumari *et al* (2022) found that most of the respondents in the age group of 50 years and above (84.62%). Many young people view agriculture as less lucrative than urban job prospects; farming income is unpredictable due to various untold reasons. Moreover, farming is sometimes perceived as a low-prestige occupation. To reverse this trend, a comprehensive approach is needed to make agriculture a more attractive and sustainable career option.

Education wise distribution of drip irrigation farmers

Table 2 presents the education-wise distribution of drip irrigation farmers across Tamil Nadu, Maharashtra, and Gujarat. The analysis indicated no statistically significant difference among the three states with respect to farmers' educational backgrounds. This suggests that education levels among drip irrigation adopters are relatively uniform across regions, implying that education is not a key differentiating factor influencing adoption in this context. However, a closer look at the numerical distribution revealed certain state-wise trends. In Tamil Nadu, a higher proportion of farmers (30.8%) had education up to the middle school level, whereas in Maharashtra, most farmers (31.7%) had completed high school, and in Gujarat, an equal proportion (31.7%) had only primary school education. Overall, 24.7% of farmers across all states had middle school education. These findings are consistent with the observations of Shambhrakar *et al* (2018) in the Vidarbha region and Deepika *et al* (2020) in Tamil Nadu, who reported that farmers with medium levels of knowledge were predominant among drip irrigation adopters. Regional differences in education, employment opportunities, and interest in farming contribute to varying agricultural adoption patterns, emphasizing the importance of understanding local socio-economic contexts for effective policy formulation. Jumanne (2016) also highlighted that farmer's age, education, and economic factors significantly influence technology adoption. Similarly, Verma and Sharma (2017) found in Rajasthan that variables such as education, annual income, and mass media exposure had a positive and significant relationship with drip irrigation adoption. Complementing these findings, Sharma *et al* (2021) reported that, apart from education, socio-economic status, and caste, other factors like annual income, age, landholding size, media exposure, and social

participation exhibited a positive correlation with adoption levels among respondents.

Cotton farming experience wise distribution of drip irrigation farmers

Table 3 presents the distribution of farmers based on their experience in cotton farming. The analysis indicated a statistically significant relationship among the drip irrigation farmers from Tamil Nadu, Maharashtra, and Gujarat. This suggests that there is a notable difference in cotton farming experience among the three groups of farmers. Given the presence of significant variation among the groups, Duncan's Post Hoc test was employed to identify the specific differences between the states. The results of this test provided a clearer understanding of the extent and nature of variation in cotton farming experience among farmers across Tamil Nadu, Maharashtra, and Gujarat. This post hoc analysis thus helped pinpoint which state-wise groups differed significantly, offering deeper insights into the patterns of experience variation among drip irrigation adopters.

Experience in drip irrigation

Table 4 presents the distribution of farmers according to their experience in using drip irrigation. The analysis revealed no statistically significant difference among farmers from Tamil Nadu, Maharashtra, and Gujarat, indicating that their levels of experience with drip irrigation are relatively similar. This uniformity may be attributed to the widespread promotion and adoption of drip irrigation following the implementation of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) under the Micro Irrigation Scheme. The simultaneous exposure to government-supported initiatives likely encouraged many cotton farmers across states to adopt the technology around the same period, resulting in comparable experience levels. Notably, a higher proportion of adopters were found among farmers with over 20 years of overall farming experience, suggesting that experienced cultivators tend to be more receptive to improved irrigation methods. However, while experience contributes positively to the adoption process, it operates alongside other factors such as education, resource availability, flexibility in farm management, and access to information. Thus, technology adoption in agriculture is best understood as a multifaceted process influenced by the interaction of socio-economic, institutional, and experiential variables.

Farm size wise distribution of drip irrigation farmers

Table 5 presents the distribution of farmers according to their farm size. The analysis showed a statistically significant difference among drip irrigation farmers from Tamil Nadu, Maharashtra, and Gujarat, indicating considerable variation in landholding patterns across the three states. This suggests that farm size is not uniform among the respondents and may be shaped by diverse regional factors such as cropping patterns, land tenure systems, resource availability, and the extent of agricultural mechanization. Differences in state-level policies, irrigation infrastructure, and historical land distribution may also contribute to the observed variability in farm size among drip irrigation adopters.

To examine the nature and extent of this variation more precisely, Duncan's Post Hoc test was performed. The results further confirmed the presence of significant differences in farm sizes among the groups, establishing that farm size serves as a key differentiating factor in the adoption of drip irrigation across the studied regions. The findings revealed that the majority of drip irrigation farmers were smallholders in Tamil Nadu (50.0%) and Maharashtra (37.5%), whereas in Gujarat, most belonged to the medium farm size category (47.5%). These results align with the observations of Kumari *et al* (2022), who reported a significant association between landholding size and the level of drip irrigation adoption, noting that over 70% of medium-sized farmers exhibited higher adoption rates. In contrast, Kumar and Palanisami (2011) found that drip irrigation adopters typically managed larger landholdings, with an average farm size of 5.41 hectares compared to 2.28 hectares among non-adopters in the control villages. Such variations highlight the complex role of farm size in influencing technology adoption, where both small and medium farmers may actively adopt drip systems depending on regional conditions, institutional support, and perceived economic benefits.

Operational area under drip irrigation

Table 6 presents the distribution of farmers based on the area under drip irrigation. The analysis revealed a statistically significant relationship among drip-irrigated cotton farmers from Tamil Nadu, Maharashtra, and Gujarat. Medium-scale farmers are often well-positioned to adopt drip irrigation technology, as they typically have sufficient resources to invest without being burdened by the complexities of managing large-scale operations. In contrast, small

Table 5: Farm size wise distribution of drip irrigation farmers

Sr. No.	Category	Tamil Nadu		Maharashtra		Gujarat		Total	
		No.	%	No.	%	No.	%	No.	%
1.	Marginal farmers (Up to 2.5 acres)	10	8.30	10	8.30	2	1.70	22	6.1
2.	Small farmers (2.51-5 acres)	60	50.00	45	37.50	23	19.20	128	35.60
3.	Medium farmers (5.01- 10 acres)	43	35.80	41	34.20	57	47.50	141	39.20
4.	Big farmers (Above 10 acres)	7	5.80	24	20.00	38	31.70	69	19.20
F Value (Among three groups of drip users)= 23.704 **; p=0.000 (p < 0.01)									

** Significant at 1 % level

Duncan's Post Hoc test for comparison of differences (Farm size)

S.No.	Treatment Groups	Means for groups (Sub set for alpha= 0.05)		
		1	2	3
1.	T_1(Tamil Nadu Farmers)	2.3917		
2.	T_2(Maharashtra Farmers)		2.6583	
3.	T_3 (Gujarat Farmers)			3.0917

Table 6. Operational area under drip irrigation . (N=360)

Sr. No.	Category	Tamil Nadu		Maharashtra		Gujarat		Total	
		No.	%	No.	%	No.	%	No.	%
1.	Less than 3 acres	82	68.30	50	41.70	14	11.70	146	40.60
2.	3-9 acres	34	28.30	51	42.50	58	48.30	143	39.70
3.	More than 9 acres	4	3.30	19	15.80	48	40.00	71	19.70
F Value (Among three groups of drip users) =33.472**; p=0.000 (p < 0.01)									

** Significant at 1 % level

Duncan's Post Hoc test for comparison of differences – Area under drip irrigation

Sr. No	Treatment Groups	Means for groups (Sub set for alpha= 0.05)		
		1	2	3
1.	T_1(Tamil Nadu Farmers)	3.3750		
2.	T_2(Maharashtra Farmers)		5.6333	
3.	T_3 (Gujarat Farmers)			9.1792

farmers may face financial constraints and limited technical knowledge required for installation and maintenance. On the other hand, large farmers may have more intricate irrigation requirements that drip systems alone may not adequately address. Given the presence of a significant difference, Duncan's Post Hoc test was conducted to determine the specific groups where the variation occurred. The test results confirmed the extent of variation, indicating that the area under drip irrigation is not uniform and differs notably among the three categories of farmers studied.

CONCLUSION

This study represents one of the first comprehensive efforts to analyse the multifaceted dimensions of drip irrigation technology in cotton cultivation. It offers valuable insights into the socio-economic profiles of farmers and their relationship with the adoption of drip irrigation across three major cotton-growing states of India-Gujarat, Maharashtra, and Tamil Nadu. While cotton serves as a major cash crop in Gujarat and Maharashtra, it also holds considerable economic importance in Tamil Nadu. The analysis revealed that among the socio-economic

variables examined, age, education, and experience in drip irrigation showed no significant differences among farmers across the three states. In contrast, variables such as farming experience in cotton, farm size, and operational area under drip irrigation exhibited significant variation, suggesting their influence on adoption behaviour. The findings carry important policy implications, offering a robust empirical basis for policymakers to refine and strengthen micro-irrigation initiatives. Emphasis should be placed on region-specific strategies, targeted farmer support systems, and efficient technology dissemination mechanisms. Expanding the adoption of drip irrigation in cotton cultivation has the potential to enhance resource-use efficiency, promote water conservation, and contribute significantly to the goal of sustainable agricultural development, particularly in water-stressed regions of the country.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support provided by the Indian Council of Agricultural Research (ICAR) for facilitating the survey conducted across the three states. They also extend their sincere thanks to Dr. V. N. Waghmare, Director, ICAR-CICR, Dr. R. Selvarajan, Director, ICAR-NRCB and Dr. A. H. Prakash, Head, Regional Station, ICAR-CICR, Coimbatore, for their continued support, encouragement, and valuable facilitation throughout the course of this study.

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Received on 11/09/2025 Accepted on 19/09/2025