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Study on factors influencing the adoption of drip irrigation by farmers in humid tropical Kerala, India

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Abstract

Adoption of drip irrigation in Kerala State of India is very low and potential exists to increase its adoption in the State. A field survey was conducted in two districts to determine the major factors influencing farmers' adoption of drip irrigation and to draw conclusions that will help in developing policy and institutional interventions to encourage the adoption. The results indicated that adoption index of farmers is higher in Kozhikode, when compared with the Thrissur district. However, with respect to different crops, adoption index is not statistically significant. Socioeconomic characteristics such as age, education, experience, land holding size, etc. have a positive influence on drip irrigation adoption index by farmers. Farmers have realized yield improvement in the range of about 13% to 47% through drip irrigation, when compared to surface method of irrigation for arecanut, coconut and nutmeg. High productivity and income from cultivation of crops like coconut, arecanut and nutmeg have acted as an incentive to adopt the costly system of drip irrigation in the case of both Kozhikode and Thrissur farmers. The number of drip irrigation components and type of emitters indicated a significant and linear response for drip irrigation adoption. The reported constraints experienced by farmers include rainfall, clogging of drippers, high initial cost, inadequate subsidy, difficulty in getting subsidy, etc. This information will help to prioritize the factors that affect adoption decisions and provide insights for improving the crop and water productivity.

Keywords: Adoption index; Reasons and Constraints; Crop productivity; Policy.

Introduction

Significant water shortage is being experienced in many countries, particularly in India. Since agriculture is the largest water consumer (84%) in India, more prudent use of water in agriculture needs to be the first priority (NITI Aayog, 2015). Water use per unit irrigated area has to be reduced in response to limitations in water availability and other associated environmental and societal problems (Surendran et al., 2014). One of the scientifically proven ways to reduce the total water required for irrigation is to adopt micro irrigation (drip and sprinkler), which can improve crop yield per unit volume of water used (Jayakumar et al., 2015).

In Kerala State of India, productivity of most of the crops is low, when compared to other States, mainly due to lack of irrigation and low soil fertility. Only 16% of the gross cropped area is irrigated in the State (State Planning Board, 2011). Even though Kerala receives an average annual rainfall of 3000 mm, its distribution is spatially and temporally uneven. The State experiences a long summer period (Jan – May), resulting in moisture

stress for about six months. Hence, irrigation during summer is necessary for improving crop productivity in the State. However, there are limitations to adoption of conventional surface irrigation methods in Kerala such as water scarcity, undulating topography, high infiltration rate and low water holding capacity of the major soil type of the State, namely, lateritic soil (Surendran et al., 2014; Surendran et al., 2015). Under these circumstances, micro irrigation methods such as drip irrigation have relevance in Kerala.

Drip Irrigation

About 80% of the world's irrigated area is under surface irrigation methods, which have a use efficiency of 30-50% only. Drip irrigation was introduced in India for commercial adoption in early seventies and its growth has gained momentum in the last few years only, primarily due to the subsidy extended by Central and State Governments. India ranks first in the area under drip irrigation with 18,97,280 ha (ICID, 2015). Large chunk of money has been provided by Government agencies in India in the form of subsidy to farmers for installing micro irrigation methods including drip irrigation.

Drip irrigation is an efficient method of providing water directly to the root zone, minimizing conventional losses such as deep percolation, runoff and soil erosion. Unlike surface irrigation, drip irrigation is more suitable and economical if it is introduced in water scarce areas with undulating topography, shallow and sandy soils and for widely spaced high value crops. It also permits the utilization of fertilizers, pesticides and other water-soluble chemicals along with irrigation water, resulting in higher profit and better yields and quality of product. Many researchers have attempted to study the impact of drip irrigation and found that it produces the desired positive impacts in terms of water and crop productivity (Narayanamoorthy, 2005; Narayanamoorthy, 2008; Thampan, 2004; Namara et al., 2005; Jat et al., 2011, Indira Devi et al., 2012; Saskia van der Kooija et al., 2013; Jayakumar et al., 2014; Jayakumar et al., 2015).

Even though there are several scientifically proven positive effects for micro irrigation methods like drip irrigation, the area under micro irrigation is very low in Kerala (15885 ha), when compared to other States in India such as Maharashtra, Karnataka, Gujarat and Tamil Nadu. Hence, there exists huge potential to increase the area under micro irrigation in the State (Rane, 2011). Adoption rate of drip irrigation in the State is lower than what was predicted due to the difficulties associated with the ecological and socioeconomic constraints that exist in this humid tropical region. Studies on factors that influence adoption of drip irrigation by farmers are less, especially in humid tropics. A study on this aspect has been carried out in Kozhikode and Thrissur Districts of Kerala State in India. The results are expected to help in developing policy and institutional interventions to encourage adoption.

Materials and Methods

Study location

Kerala State is located between 8^0 15' N and 12^0 50' N latitudes and between 74^0 50' E and 77^0 30' E longitudes. The selected districts for the current study are Kozhikode in northern part of Kerala and Thrissur from central part of Kerala (Figure 1). Kozhikode district is falling in parts of Survey of India Toposheets 58 A and 49 M. It is one of the coastal districts of Kerala. This district is surrounded on the north by Kannur district, on the east by Wayanad district, on the south by Malapuram district and on the west by Lakshadweep Sea. Thrissur District falls in the Survey of India Topo sheet No. 58 B

and 49 N. It is limited on the north by part of Malappuram and Palakkad districts, on the east by Palakkad district and Coimbatore district of Tamil Nadu, on the south by Ernakulam district and on the west by the Arabian Sea. The site characteristics of the selected districts are given in Table 1. Average monthly rainfall for both the districts are shown in Figure 2 and it indicates the moisture stress experienced in these districts for the period of 4 to 6 months. In each district, farmers were selected through stratified random sampling with respect to four cultivated crops, namely, coconut, arecanut, banana and nutmeg from the list of drip irrigating farmers obtained from the Dept. of Agriculture, Government of Kerala. Coconut is a widely spaced crop with spacing of 7.5 × 7.5 m, while arecanut and banana are closely spaced crops with spacing of 2 × 2 m.

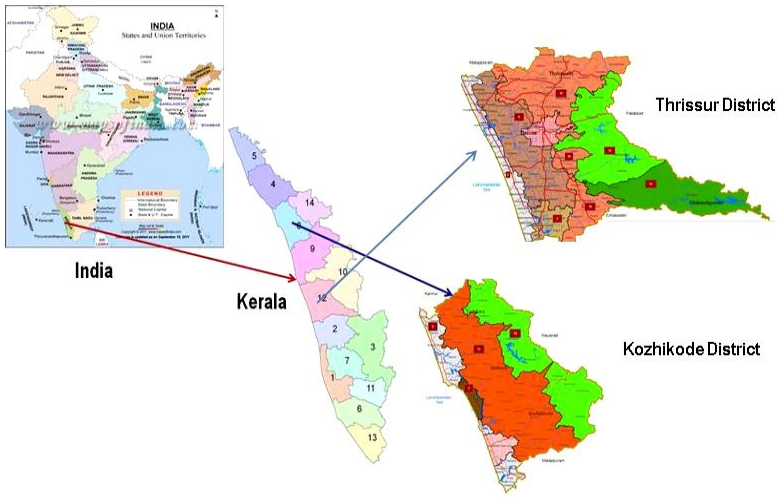

Figure 1. Geographic location of the selected study area.

Table 1. Site characteristics of selected districts under the study.

Parameters	Districts	
	Kozhikode	Thrissur
Latitude/ Longitude	North latitudes 11º 08' and 11º 50' and East longitudes 75 º 30' and 76 º 8'	North latitudes 10^0 10' 22'' and 10^0 46' 54''; and East longitudes 75^0 57' 20'' and 76^0 54' 23''
Toposheet details	Falling in parts of Survey of India Toposheets 58 A and 49 M	Survey of India Topo sheet No. 58 B and 49 N
Mean annual maximum Temperature (^{0}C)	34.6 (Apr)	35.8 (March)
Mean annual minimum Temperature (^{0}C)	18.9 (Dec)	22.1 (December)
Mean annual Rainfall (mm)	3438	2893
Major soil types	Lateritic soil, alluvial soil and forest loam	Lateritic soil, Coastal alluvial soil, riverine alluvium, Brown hydromorphic soil, hydromorphic saline soils and forest loamy soil
Major crops grown	Rice, coconut, arecanut, banana, Tapioca and vegetables	Rice, coconut, arecanut, banana, tapioca, nutmeg, chillies, mango and vegetables
Gross cropped area (ha)	200365	170057
Gross irrigated area (ha)	6433	78167

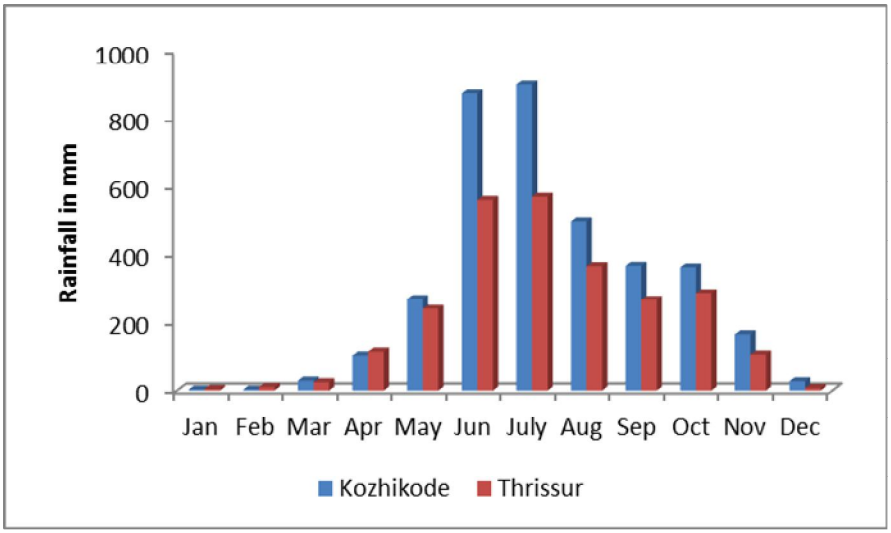

Figure 2. Average monthly rainfall of Kozhikode and Thrissur Districts.

Methodology

For the purpose of the study, the heads of the selected farmer households were interviewed (usually the household head is implicitly assumed to be the sole decision maker in adoption studies) using a structured interview schedule, which covered eight items considered for quantification of drip irrigation adoption index of farmers (the dependant variable of the study), socioeconomic characteristics of farmers such as age, educational status, farming experience, landholding size and non-farm income (the independent variables), reasons for adopting drip irrigation, constraints in continuing adoption of drip irrigation, number of crops cultivated and yield of crops under drip irrigation and traditional method of surface irrigation. The eight items considered for quantification of drip irrigation adoption index were also considered as independent variables in the study. The description of the variables is presented in Table 2. To guide the development of the formal questionnaire, an informal survey was conducted using interviews with key informants including technical experts (subject matter specialists), Government officials, non-government organizations and other research agencies engaged in drip irrigation.

Adoption of drip irrigation by farmers was quantified as adoption index, which is the weighted total score of eight items of drip irrigation adoption shown under Sl. No. 6 to 13 in Table 2. Weightage was allotted based on the relative importance of each item to adoption of drip irrigation. The sum of weights of all the items is equal to one. The score obtained by farmers for each item was multiplied with the weight age to get the weighted score of the item. Interview was carried out among a sample of 100 farmers each in the selected two districts of Kerala, namely, Thrissur and Kozhikode. In each district, farmers were selected through stratified random sampling with respect to four cultivated crops, namely, coconut, arecanut, banana and nutmeg from the list of drip irrigating farmers obtained from the Dept. of Agriculture, Government. of Kerala.

Table 2. Description about variables of the study.

Sl. No.	Variable	Details	Method of Scoring/Quantification
1.	Age	in years	years
2.	Educational status	Up to 4th class in school	1
		4th to 7th class in school	2
		8th to 10th class	3
		Pre-Degree	4
		Degree and above	5
3.	Farming experience	in years	years
4.	Landholding size	Extent of total landholding	Hectares (ha.)
5.	Non-farm income	Income from sources other than agriculture	Percentage of total income
6.	No. of crops	No. of crops cultivated	Number
7.	Area under drip irrigation for various crops	in ha	Percentage of total cultivated area
8.	No. of years of drip irrigation adoption	1 to 5 years	1
		6 to 10 years	2
		11 to 15 years	3
		>15 years	4
9.	Components installed in drip irrigation system	Number of components	Number
10.	Type of emitter used in drip irrigation system	Micro tube emitter	1
		Ordinary emitter	2
		Pressure compensating emitter	3
		Both pressure compensating emitter and micro tube emitter	4
11.	Continuation of drip irrigation adoption	Yes	2
		No	1
12.	Practicing drip fertigation	Yes	2
		No	1
13.	Soil application of fertilizers under drip irrigation	Yes	2
		No	1
14.	Availing subsidy from Agriculture Dept. for installation of drip system	Availed	2
		Not availed	1

Statistical analysis

The data was subjected to statistical scrutiny viz., ANOVA (Analysis of Variance), Student-t test, Regression and Pearson Correlation matrix as per methods suggested by Gomez and Gomez (1984) and executed with the software SYSTAT and MS Excel. Wherever the results were significant, critical differences were worked out at probability level $P<0.05$ and $P<0.01$. The non-significant differences ($P\geq0.05$) were denoted as ns.

The influence of socioeconomic characteristics such as age, education, experience, land holding size on drip irrigation adoption index of farmers was analyzed through ANOVA. Age (years) was grouped into four categories viz., less than 46, 47 to 55, 56 to 62 and 63 to 80 and assessed for the influence of these groups on drip adoption index.

Farming experience (years) was grouped into less than 10, 11 to 20, 21 to 30 and more than 30 and tested for its significance against drip adoption index. Land holding size (ha) of farmers was grouped as less than 0.75, 0.75 to 1.00, 1 to 2 and more than 2 and analyzed for the significance of these groups on drip adoption index. Similarly, number of crops cultivated was grouped into four viz., 1, 2, 3 and 4 and analyzed using ANOVA for its influence on drip adoption index. The score for eight items of drip irrigation adoption were tested for their influence on the weighted adoption index by linear regression and Pearson correlation matrix analysis.

Reasons for drip adoption and constraints in continuing drip irrigation

The relative importance of the reasons for adoption of drip irrigation and the constraints in continuing adoption of drip irrigation reported by farmers were ranked using the Garrett Ranking Technique (Garrett and Woodworth, 1977). This technique is used to rank a set of factors as perceived by the respondents. The order of merit assigned by the respondents is converted into per cent position and scores using the formula and Garrett table, as suggested by Garrett and Woodsworth (1977). For each factor, the mean scores are worked out from the total scores of various respondents. The factors are arranged in descending order based on the mean score. The factor with the highest mean score is considered the most important one.

Relationship between reasons for adoption and drip irrigation adoption index

The first and second ranked reasons reported by farmers for adoption of drip irrigation, namely, water scarcity and more labour requirement for surface irrigation methods were considered for analyzing their influence on drip adoption index through *'t'* test.

Crop productivity

The yield data of drip irrigation adopters and traditional surface irrigation method adopters were analyzed for the influence of irrigation methods through t-test for the crops, namely, coconut, arecanut and nutmeg.

Results and Discussion

Drip irrigation adoption index

Student-t test showed significant differences between the adoption index in the two districts for all the crops (Table 3). The mean adoption index of farmers for crops is higher in Kozhikode when compared to Thrissur district and the variation in the index is statistically significant. However, it may be seen from Table 3 that there is not much crop-wise difference in adoption index of farmers in both districts and there is no difference between districts. This indicates that marked variation does not exist in adoption of various items of drip irrigation (which have been considered in the quantification of adoption index) between widely spaced crops like coconut and closely spaced crops like banana and arecanut. This is the case, despite the fact that drip irrigation is comparatively more costly for arecanut, when compared to coconut. This finding indicated that farmers are willing to follow the guidelines of the drip irrigation firms/Agriculture Department on the number of drip irrigation components to be installed under the system, emitters to be used, etc.

Table 3. Crop-wise drip irrigation adoption index of farmers.

Crop	Mean drip irrigation adoption index*		*t stat*
	Kozhikode District	Thrissur District	
Coconut	74.7	57.4	-6.6201[a]
Arecanut	74.9	57.8	-4.9926[a]
Nutmeg	77.2	55.6	3.6403[b]
Banana	72.5	57.2	-2.4578[c]
District wise mean	74.83	57.0	9.60[c]
Crops	ns	ns	

* expressed as % of maximum possible adoption index.
[ns] Non-significant (P≥0.05); [a] Significant at P<0.001; [b] Significant at P<0.01; [c] Significant at P<0.05.

The score for number of drip irrigation components installed by the farmers and type of emitters used showed significant difference between districts for all the selected crops (Table 4). The score of farmers for years of drip irrigation adoption shows a significant difference between the two districts in the case of nutmeg only (Table 4).

The data revealed that there is no perceptible difference between the two districts with regard to the number of farmers availing drip irrigation subsidy from the Agriculture Department. In Thrissur district, all farmers are continuing adopting the drip irrigation during the period of this study, while in Kozhikode only about 43% farmers adopted this technique. None of the farmers in the two districts are practicing fertigation through drip irrigation. They were of the opinion that cost of drip fertigation system is very high. Most of them are also not aware about the impact of fertigation on crops.

Table 4. Score of farmers for various items of drip irrigation adoption.

Crop	Item	Mean score for the item *		*t-test*
		Kozhikode	Thrissur	
Coconut	Drip irrigation components used	79.31	42.04	-8.8701[a]
	Type of emitter used	93.96	61.71	-6.4327[a]
Arecanut	Drip irrigation components used	78.91	40.65	-6.8790[a]
	Type of emitter used	91.25	63.63	-3.6470[a]
Banana	Drip irrigation components used	78.57	38.57	-4.0097[a]
	Type of emitter used	100.00	62.00	-4.6146[a]
Nutmeg	Drip irrigation components used	73.81	42.85	-2.8014[b]
	Type of emitter used	83.33	54.54	2.3612[c]
	Years of drip irrigation adoption	79.17	34.09	-5.0652[a]

* expressed as % of maximum possible score for the item.
[a] Significant at P<0.001; [b] Significant at P<0.01; [c] Significant at P<0.05.

Regression and Pearson correlation analysis

The regression analysis of the variables contributing to adoption index is discussed here. Out of these variables, number of drip irrigation components and type of emitters indicated a significant response with a linear function regression analysis (Figures 3, 4

and 5). The other variables viz., area under drip irrigation, drip continuation, fertigation and applying fertilizer in soil did not show significant response. Similar to regression analysis, Pearson Correlation matrix also followed the same trend and proved that the number of drip components, type of emitter and years of adoption is positively correlated with the weighted adoption score (Table 5). This confirms that these are the main parameters influencing the adoption of drip irrigation, as previously evidenced by t-test.

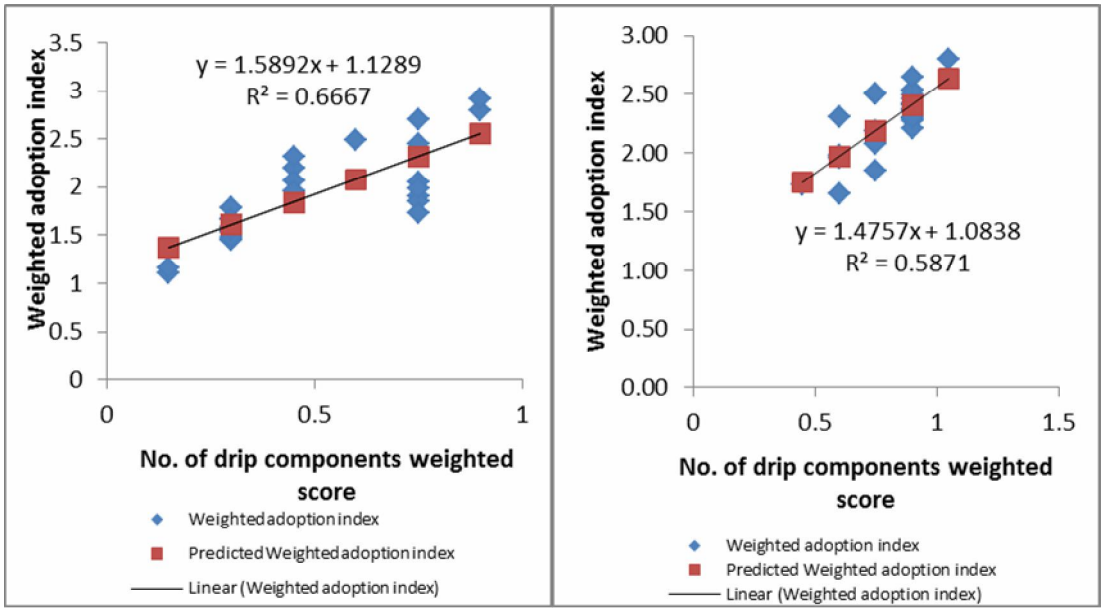

Figure 3. Regression graph of number of drip irrigation components vs. adoption index of Kozhikode and Thrissur districts.

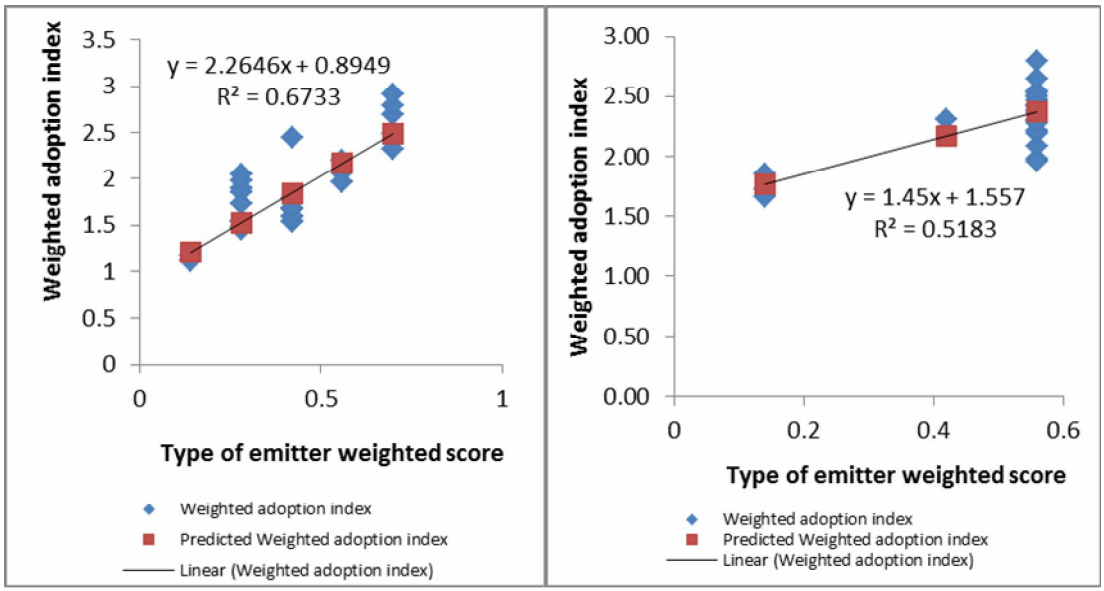

Figure 4. Regression graph of type of emitter vs. adoption index of Kozhikode and Thrissur districts.

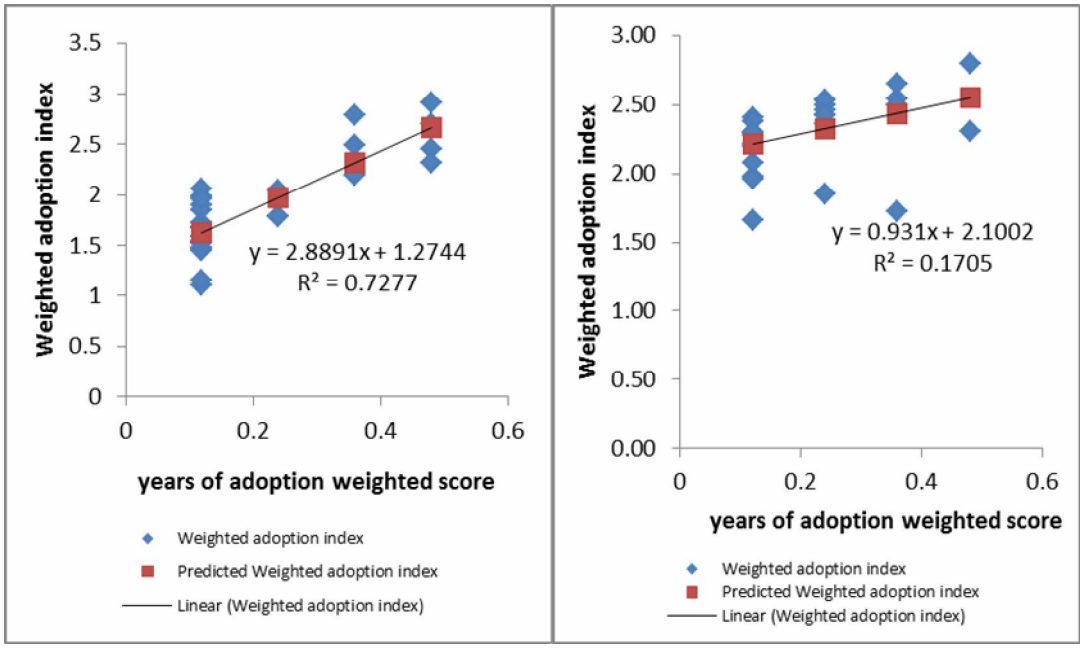

Figure 5. Regression graph of year of drip adoption vs. adoption index of Kozhikode and Thrissur districts.

Table 5. Pearson correlation matrix for variables against drip irrigation adoption index.

Variables	Thrissur	Kozhikode
Area of drip adoption weighted score	0.192*	0.323*
No. of drip components weighted score	0.817*	0.766*
Type of emitter weighted score	0.821*	0.720*
Subsidy weighted score	0.075^{ns}	0.033^{ns}
Years of adoption weighted score	0.853*	0.413*
Drip continuation weighted score	0.020^{ns}	0.024^{ns}
Fertigation adoption weighted score	0.098^{ns}	0.009^{ns}
Applying fertiliser in soil weighted score	0.010^{ns}	0.006^{ns}

^{ns}, * Non-significant ($P \geq 0.05$) and significant for $P < 0.05$.

Influence of socioeconomic characteristics on drip irrigation adoption index of farmers

The influence of socioeconomic characteristics on drip irrigation adoption index of farmers was analyzed through ANOVA and the results are discussed below. Age group was found to influence the drip adoption rate significantly ($P < 0.05$; Table 6). Younger farmers (less than 46 years of age) were found to be relatively better adopters of drip irrigation technology than the older ones. The latter group was not very much convinced about meeting the crop requirement through drip irrigation, when compared to surface irrigation. According to the theory of human capital, young members of a farming family have a greater chance of absorbing and applying new knowledge (Sidibe, 2005). Thus, apparently the older people are less likely to adopt the drip irrigation.

Significant difference in adoption index of farmers was also observed between different categories of farming experience. It can be observed from Table 6 that in both Kozhikode and Thrissur districts, the average drip irrigation adoption index of comparatively younger farmers (farming experience of 0 to 10 years) is more than the higher experience categories. This indicates that younger farmers are more ready to adopt new technologies, in contrast with an earlier study reported by Shashidara et al. (2007) confirming the above statement.

Table 6. ANOVA of age and experience on adoption index.

Age group in years	Thrissur	Kozhikode	Experience in years	Thrissur	Kozhikode
Less than 46	1.82	2.56	0-10	1.96	2.49
47-55	1.50	2.30	10-20	1.69	2.29
56-62	1.44	2.30	20-30	1.70	2.26
63-80	1.47	2.19	More than 30	1.71	2.18
SEd	0.03	0.01	SE	0.03	0.03
CD (P=0.05)	0.212	0.212	CD (P=0.05)	0.242	0.194

According to Tassew (2004), farmers with higher levels of educational attainment are more likely to adopt new technologies or practices than less educated farmers. The results of the present study also proved this, with education significantly influencing drip irrigation adoption (data not shown) in agreement with Daberkow and McBride (2003). Educated farmers have more access to information and better awareness about the advantages of micro irrigation, which ultimately helps them in adoption. Education not only increases the level of awareness, but also gives the confidence to adopt new technology.

Land holding size is also found to be an important factor influencing drip irrigation adoption by farmers. There exists a significant difference in adoption index between the maximum size group and others (Table 7). Land holding size is having influence in drip irrigation adoption because larger the size of farms, lower will be the initial investment cost since the components like head unit, filter, tank, pumpset will be common for 0.25 and 2 ha landholding size as mentioned by Palanisami et al. (2012). Table 7 also shows that number of crops cultivated by the farmer did not affect the adoption index.

Table 7. ANOVA of landholding size and number of crops on adoption index.

Landholding in ha.	Thrissur	Kozhikode	No. of crops	Thrissur	Kozhikode
less than 0.75	1.72	2.16	1	1.80	2.32
0.75-1	1.76	2.18	2	1.84	2.30
1-2	1.75	2.21	3	1.82	2.29
more than 2	2.04	2.61	More than 4	1.81	2.31
SEd	0.04	0.02	SE	0.04	0.03
CD (P=0.05)	0.216	0.216	CD (P=0.05)	ns	ns

In Thrissur district, non-farm income of farmers is found to be an important factor influencing drip irrigation adoption by farmers (Table 8). There exists a significant difference in adoption index between farmers under various categories of non-farm income, namely, < 25% and 25 to 50%, < 25% and 50 to 75% and between 25 to 50% and 50 to 75% (Table 8). It can be observed from the table that farmers with < 25% non-farm income have a comparatively lower drip adoption index (44.72) than 25 to 50% category (53.53) and 50 to 75% category (62.52). This means that farmers getting more income from occupations other than agriculture are economically better prepared to adopt costly irrigation methods like drip irrigation. This is relevant in a state like Kerala, which has an unprofitable farming system for many farmers. Further, one of the problems reported by both farmers and officials in this study is that even 90% subsidy provided for drip irrigation by the Government works out to only about 50% to 60% of the actual expenses at the field level, since cost of installation of drip irrigation system is not covered under this. This is a drawback of the institutional mechanism related to the drip irrigation scheme of the Government. Under the above circumstances, it is only logical that higher income farmers are in a comparatively better position to adopt irrigation systems like drip irrigation than farmers with less income.

Table 8. Influence of non-farm income on drip irrigation adoption index of farmers in Thrissur District.

Group	Farmers with non-farm income (%)	Mean drip irrigation adoption index*	t-test
< 25 vs 25-50	< 25	44.72	2.44691**
	25-50	53.53	
< 25 vs 50-75	< 25	44.72	2.77644**
	50-75	62.52	
25-50 vs 50-75	25-50	53.53	2.44691**
	50-75	62.52	

* Expressed as % of maximum possible adoption index, ** Significant at P<0.01.

Reasons for adopting drip irrigation

The ranked reasons for adoption of drip irrigation are shown in Table 9 for farmers of Kozhikode and Thrissur districts. The most important reason to adopt drip irrigation in both districts is the difficulty of farmers to adopt more water consuming traditional irrigation methods due to water scarcity. This is one of the main reasons why only about 20% of cropped area under coconut, the main upland crop of Kerala and 35% of the cropped area under arecanut are irrigated in the state (Source: Farm Guide 2011. Department of Agriculture, Government of Kerala).

In both districts, farmers attribute a higher labour requirement under traditional irrigation methods as the second important reason for adopting drip irrigation. High productivity and income from cultivation have acted as an incentive to adopt the costly system of drip irrigation in the case of both Kozhikode and Thrissur farmers (Table 9). It can also be made out from the table that good crop yield, which can be obtained through drip irrigation, has been an important factor motivating farmers in both the districts to adopt drip irrigation.

It is interesting to note from Table 9 that in both districts, subsidy provided by the Agriculture Department has not been a prominent contributing factor in the adoption of drip irrigation. During discussions with the officials of the Agriculture Department, it has been understood that some problems exist with regard to the subsidy component under the drip irrigation scheme of the Department. This is an institutional factor contributing to less adoption of drip irrigation in Kerala.

Table 9. Reasons for adopting drip irrigation.

Sl. No	Reason	Kozhikode District	Thrissur District
		Rank*	Rank*
1	Unable to adopt traditional surface irrigation methods due to water scarcity	1	1
2	Surface irrigation methods involve more labour, which is costly	2	2
3	Good crop yield, which is comparable to yield obtained under surface irrigation, can be obtained through drip irrigation	3	4
4	Subsidy provided by the Agriculture Department	4	5
5	Difficulty to adopt surface irrigation methods on sloping land	5	7
6	Drip irrigation saves time, when compared to surface irrigation methods	Not reported	3
7	Drip irrigation can be managed by the farmer himself, without depending on labours	Not reported	6

* Ranked using Garrett Ranking Technique.

Among different states, the Micro Irrigation (Drip and Sprinkler) promotion and subsidy scheme is more successfully implemented in states like Andhra Pradesh, Tamil Nadu, Maharashtra and Gujarat. One of the major reasons reported by Palanisamy et al. (2012) for this is that these states have created a special project cell / company (SPV-Special purpose vehicle) with the sole responsibility of promoting and implementing micro irrigation schemes of state and central governments. In Andhra Pradesh, it is APMIP (Andhra Pradesh Micro Irrigation Project), Tamil Nadu it is TANHODA – Tamil Nadu Horticultural Development Agency) and in Gujarat, this is GGRC (Gujarat Green Revolution Company Ltd), respectively. However, in Kerala, drip irrigation promotion role is still vested with the Agriculture Department, for whom the implementation of micro irrigation scheme is one of their several responsibilities. Hence, it does not receive the required attention by officials.

Relationship between reasons for adoption and drip irrigation adoption index

The first and second ranked reasons for adoption of drip irrigation, namely, water scarcity and more labour requirement for surface irrigation methods were considered for analyzing their influence on drip irrigation adoption index of farmers through the t-test. The t-test was significant in the case of farmers of Thrissur district (Table 10). The mean adoption index of farmers in the district mentioning water scarcity as the reason for drip irrigation adoption is 61.78%, while it is 50.82% for farmers citing more labour requirement for surface irrigation methods as the reason. This indicates that farmers facing water scarcity are more innovative in adoption of drip irrigation.

Table 10. Influence of reasons for adoption on drip irrigation adoption index of farmers in Thrissur district.

Details	Reason for adopting drip irrigation		t-test
	Water scarcity	More labour requirement under surface irrigation methods	
Mean drip irrigation adoption index* of farmers mentioning the reason	61.78	50.82	2.6974[a]

* % of maximum possible adoption index, [a] Significant at P<0.01.

Constraints in continuing drip irrigation

Constraints reported by farmers of the two districts in continuing the adoption of drip irrigation, which have been ranked using Garrett Ranking Technique, are shown in Table 11.

Clogging of emitters and laterals is ranked as the second important constraint in Thrissur, while it is the most important constraint in continuing drip irrigation adoption for Kozhikode drip irrigation farmers. Clogging is an important universal problem under drip irrigation. To overcome this, depending on water quality, efficient filtration using sand / gravel filters, etc. may be necessary. However, field level observations showed that none of the farmers under this study have installed such advanced filtering units. This is due to the high cost of these filters which many farmers in Kerala are not willing to adopt under the non remunerative nature of farming existing in the state. Other main constraints reported by farmers include damage to the drip system due to falling of coconuts, rodents, etc., the high cost of drip irrigation components, the non availability of components, the difficulty to do inter cultivation when drip system is there in the field, the lack of after sales service from drip irrigation firms, the difficulty to fold the pipes during rainy season and lack of sufficient awareness / technical assistance from the Agriculture Department (Table 11).

Table 11. Constraints reported by farmers in continuing drip irrigation.

Sl. No	Constraint	Kozhikode District	Thrissur District
		Rank*	Rank*
1	Clogging of emitters and laterals	1	2
2	Non availability of drip irrigation components in the market	2	Not reported
3	Lack of after sales service from drip irrigation firms	3	Not reported
4	Difficulty to fold pipes during rainy season	4	6
5	Damage to pipes due to falling coconuts, rodents etc.	5	1
6	High cost for replacement of drip irrigation components	6	3
7	Lack of sufficient awareness programs/ technical assistance from the Agriculture Department	7	5
8	Difficulty to maintain proper pressure in the pipes/emitters for getting the required discharge	8	Not reported
9	Difficulty to do inter cultivation when drip irrigation system exists	Not reported	4

* Ranked using Garrett Ranking Technique.

Many authors have studied the constraints faced by farmers in adopting drip irrigation. The reported constraints experienced by farmers are the initial high cost, the inadequate subsidy, the difficulty in getting subsidy, the clogging of drippers and cracking of laterals, the non- uniformity of subsidy, the ordinate delay in processing of loan application, an improper design of the system, the lack of availability of technical input and after sales service, damage due to rats and squirrel and the high cost of spares and components (Prichard, 1991; Sivanappan and Lamm, 1995; Narayanamoorthy, 2005; Kumar, 2001; Kumar, 2004; Palanisami et al., 2012). Many of these constraints have been reported by farmers in this study as demonstrated above.

Based on discussions with the Agriculture Department officials under this study in various districts of Kerala, it has been understood that sufficient training programs are not arranged for farmers and officials on drip irrigation. This can be considered as an important drawback in the drip irrigation scheme of the Department. Accordingly, both farmers and officials are not properly aware of various aspects of the irrigation technique, which will contribute to less adoption of the irrigation technique in the state. It may be noted that this is the situation, even when, provision exists under the drip irrigation scheme of the Government for capacity building through training/seminars. Since many of the officials are also not aware about the technical aspects of drip irrigation system they are not in a position to impart the required assistance to farmers on aspects such as design, operation and maintenance of the system. This is an important limitation for farmers adopting an improved technique like drip irrigation.

Difficulty to fold drip irrigation pipes during rainy season, as reported by farmers, is an important constraint in Kerala, where the rainy season extends to about six months. During this period, drip irrigation pipes and accessories cannot be left in the field. This is mainly because they get buried under weed growth during the rainy season, with a possibility of damage of the system during weeding operation. This may be overcome to a great extent by using sub surface (buried pipe system) drip irrigation. This can also overcome the following problems which have been reported by farmers, namely, damage to the drip system due to falling of coconut / rodents and difficulty to do inter cultivation when drip system is there in the field. However, sub surface drip is more costly than the surface system. Hence, under the existing situation, where, farmers already incur considerable expenditure even after getting subsidy for drip installation, this does not appear to be a feasible proposition in Kerala for majority of the farmers.

Non availability of drip irrigation components in the market and lack of after sales service from drip irrigation firms have been reported by the farmers in this study as constraints in continuing drip irrigation. Since the level of adoption of drip irrigation in Kerala is not up to the expected level, companies dealing with irrigation systems normally concentrate more on sprinklers, which have a comparatively better market than drip irrigation. This problem can be addressed only if they are able to achieve an increase in their market base for drip irrigation system. This requires concerted effort of the Agriculture Department to work out suitable strategies for increasing adoption of the irrigation technique among farmers in Kerala using the subsidy provided by them.

Crop yield under drip irrigation

Data on crop yield obtained by farmers under drip irrigation is given in Table 12. From this, it can be inferred that drip irrigation gives 19.11% improvement in yield for coconut, 13.3% for arecanut and 47.1% for nutmeg than surface method of irrigation,

which also consumes more water. The positive effect of drip irrigation on yield of crops such as coconut, arecanut and banana have been reported based on studies carried out by CWRDM in Kerala (CWRDM, 2003; CWRDM, 2011). Similarly, the importance of drip irrigation for various crops in Kerala from an agronomic and social perspective has also been established in a study by CWRDM (Madhava Chandran et al., 2005).

Table 12. Yield of crops under drip irrigation.

Crop	Crop yield under	
	Surface method of irrigation	Drip irrigation
Coconut	68 nuts/palm/year	81 nuts/palm/year
Arecanut	3.0 kg dried nut/palm/year	3.4 kg dried nut/palm/year
Nutmeg	8.5 kg/plant/year	12.5 kg/plant/year

Perceptions of Agriculture Department officials on drip irrigation

Our study confirms that the rate of adoption of drip irrigation technology is still very low, compared to its potential, even after substantial promotional efforts by different agents. The poor adoption can be attributed to many factors such as clogging of drippers, high cost, complexity of the technology and other socio-economic issues like lack of access to credit facilities, fragmented landholdings, localized crop pattern, rainfall pattern in Kerala, etc. Keeping this in mind some focused group discussions conducted with the officials of the Agriculture Department in various districts of Kerala to identify the ways and means for improving adoption of drip irrigation revealed the following:

a. In most of the districts, drip irrigation adoption by farmers is not satisfactory. However, when subsidy to farmers was increased to 90% by the Department, drip irrigation adoption improved significantly in Palakkad district, which faces severe water scarcity.

b. Lack of awareness among farmers on drip irrigation is an important constraint for its adoption. Similarly, lack of technical knowhow for Agricultural officers regarding design and maintenance of drip irrigation is another constraint.

c. Water scarcity, saving in labour and water and the possibility of yield increase through adoption of drip irrigation are factors contributing to the adoption of drip irrigation. In addition to water saving, the extension programmes by the Agriculture Department should concentrate on creating awareness on higher yield and income, which can be obtained through drip irrigation for various crops.

d. Since the installation cost of drip irrigation system is not included in the subsidy provided to farmers, they have to incur expenditure towards this. Similarly, the cost estimates of drip irrigation system approved by the Department have not been updated, even when drip irrigation companies have increased the costs. These factors de-motivate farmers in adopting drip irrigation.

e. Sufficient number of authorized dealers of drip irrigation is not available for farmers to avail their services. From discussion with the drip irrigation dealers, it has been understood that this is mainly because of the low market reach of drip irrigation in Kerala, where more number of farmers adopt sprinkler than drip irrigation.

g. Usually, there exists a delay in getting administrative sanction for drip irrigation subsidy scheme from the Government, resulting in lack of sufficient time for the

Agriculture Department to identify interested farmers.
h. Subsidy cannot be provided to farmers who install drip irrigation on leased land. This is an important constraint in Kerala now, when more and more farmers have started cultivation of remunerative crops such as banana and vegetables on land taken on lease.

Conclusions and Recommendations

Our studies from two districts of Kerala State in India indicate that water scarcity, labour and water saving feature of drip irrigation and possibility of yield increase through adoption of drip irrigation are the main factors contributing for the adoption of drip irrigation among farmers. Among districts, the mean adoption index of farmers for crops is higher in Kozhikode when compared with Thrissur and the difference is statistically significant. Among different crops in districts, adoption index was not statistically significant. This implies that marked variation does not exist between widely spaced crops like coconut and closely spaced crops like banana and arecanut in the adoption of various items of drip irrigation, despite the fact that drip irrigation is comparatively more costly for banana and arecanut, when compared to coconut due to the difference in crop spacing. Socioeconomic characteristics such as age, education, experience, land holding size, etc. had a positive influence on drip irrigation adoption index of farmers. The main constraints experienced by farmers include clogging of drippers, high initial cost, inadequate subsidy, difficulty in getting subsidy and lack of technical awareness on drip irrigation system.

Recommendations

- Reducing the capital cost of drip irrigation and drip fertigation system will help to improve adoption.
- Fertigation can be incorporated in drip irrigation system in order to increase crop productivity and income of farmers.
- A special purpose vehicle (SPV) may be established for implementation and follow up of the drip irrigation scheme. In each district, a separate project cell can be created with Project Director, Drip Engineers and other supporting staff for drip irrigation maintenance, as is the case of States like AP, Gujarat, etc.
- As an outcome of the study, one of the major recommendation is the need for technical support. Capacity building of the implementing team is necessary, which, in turn, can train farmers on the use of drip irrigation system (design, routine operation and maintenance).

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