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Irrigation efficiency in coconut gardens-A comparative analysis of different systems of irrigation

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Abstract

Coconut farmers practice different irrigation methods to overcome the water stress during the non-rainy season. A study has been undertaken to evaluate the field performance of prevailing irrigation systems, drip, sprinkler and basin irrigations, installed in farmers' field. It is evident from the study that substantial increase in yield is possible by providing irrigation to coconut. Majority of the farmers provide sufficient or more water to coconut and hence availability of water was not a limiting factor in the productivity of the palm under irrigated condition. Loss of irrigation water due to deep percolation occurred in most of the cases. Average distribution uniformity obtained by drip and sprinkler irrigations in the study is only 46%. Clogging of emitters and undulating topography are the main reasons for the poor distribution uniformity in drip irrigated plots. Clogging due to physical impurities and obstruction to the water jet due to intercrops and other vegetation are the main reasons for the poor distribution uniformity in sprinkler irrigation. In basin irrigated gardens all the farmers were doing irrigation manually and they took adequate care to distribute the applied water fairly uniformly in the whole basin. This is the reason for obtaining high distribution uniformity (90.33%) in basin irrigation. Irrigation application efficiency was less than 50% except in basin irrigation showing the improper utilization of irrigation water. In terms of volume of water, sprinkler irrigation consumed five times more water than that of drip irrigation and two times more water than that of basin irrigation in farmers' field.

Keywords: Basin irrigation, drip irrigation, irrigation efficiency, root zone wetted, sprinkler irrigation

Introduction

Coconut is the most important crop cultivated in Kerala State, that plays a vital role in the agrarian economy of the State. Even though Kerala receives an annual rainfall of 3500 mm, the distribution of rainfall is quite uneven. In North Kerala 75 per cent of the rainfall is received from June to August and the long period of summer results in moisture stress that adversely affect the coconut productivity. Lack of irrigation is one of the major reasons attributed to the low level of productivity of coconut in Kerala State (Rajagopal *et al*., 2001). The importance of irrigating coconut for sustained yield has been emphasized by many authors (Abeywardena, 1971; Varadan and Madhava Chandran, 1991).

Drip, sprinkler and basin irrigations are the prevailing irrigation systems in coconut gardens by which farmers mitigate the soil moisture stress during summer. However, for successful implementation of these irrigation technologies in farmers' field it is imperative that farmers are provided with the relevant information and timely technical guidance.

Irrigation efficiency indicates how efficiently the available water supply is being used, based on different methods of evaluation. The design of irrigation system, the degree of land preparation, and the skill and care of the irrigators are the principal factors influencing irrigation efficiency. Loss of irrigation water occurs in the conveyance and distribution system, non uniform distribution of water over the field, percolation below crop root zone, and with sprinkler irrigation evaporation from the spray and retention of water on the foliage. The losses can be held to a minimum by adequate planning of the irrigation system, proper design of the irrigation method, adequate land preparation and efficient operation of the system.

It is worthwhile to evaluate the performance of these irrigation systems installed in farmers field so that factors associated with the proper adoption of technologies can be unearthed and meaningful interventions could be suggested for successful implementation of the irrigation system. Since no systematic studies have been conducted hitherto, a study was undertaken to evaluate the performance of three irrigation systems, drip, sprinkler and basin irrigations, commonly adopted by coconut farmers in Kasaragod district.

Materials and Methods

i. Selection of coconut gardens

The study was conducted in Kasaragod District of Kerala State. The district represents the areas in northern Kerala where rainfall distribution is quite uneven and experience a long dry spell that requires irrigation and an effective onfarm water management. From Kasaragod District all the four development blocks, Manjeswar, Kasaragod, Kanhangad and Nileswar, were selected for the study. The list of farmers adopting drip, sprinkler or basin irrigation systems in their farm was obtained from the office of the concerned Assistant Director of Agriculture. From each block 45 farmers, 15each adopting drip, sprinkler and basin irrigation, were randomly selected. However, technical performance was evaluated in 58 drip irrigated plots, 62 sprinkler irrigated plots and 72 basin irrigated plots. The same was then compared with rain fed coconut palms from 106 rain fed plots.

ii. Measurement of irrigation efficiency indicators

Various indicators to assess the efficiency of irrigation systems and method of assessing the same are decided as follows.

Irrigation distribution uniformity

Efficiency of an irrigation system depends upon the degree of uniformity of water application (Bralts *et al.*, 1987, Bucks *et al.*, 1982). Jose *et al*, 2004 determined the uniformity distribution and its economic effect on irrigation management. For finding out the distribution uniformity of the sprinkler irrigation, catch can method was used (Jarjuelo *et al.*, 1999). Water from the sprinkler was collected in cans of uniform openings laid out in a square grid pattern. Thirty two samples were collected from a square grid pattern from sixteen points. From each point two samples were collected and average of these two was taken as the sample from that point.

The non-uniformity of emitter discharge is a major problem in drip irrigation and is the result of several factors. The more important of these are the hydraulic and emitter discharge variation (Bucks *et al*., 1982). At present several methods are used for estimating field uniformity. In the present study, statistical uniformity was worked out for analyzing the uniformity of emitters by measuring their discharge rate using a measuring jar and stopwatch as described by Bralts and Kesner (1982). The general criteria adopted for an acceptable statistical uniformity coefficient were 90% or greater - excellent, 80 to 90% - very good, 70-80% - fair, 60-70% - poor and below 60% - unacceptable.

As the basin irrigation is manual in operation the uniformity will largely depends on the person doing irrigation. The discharge from the pipe was monitored at sixteen locations in each plot and the uniformity was worked out.

Water application efficiency

Water application efficiency is a measure of how efficiently water is applied to the field (Bralts *et al.*, 1987). This is expressed by

$$Ea = Ws \times 100/W_f$$

Where

Ea = Water application efficiency, per cent

Ws = Water stored in the root zone of the plant

W_f = Water delivered to the field

For this, soil samples before and after irrigation was collected from four depths, 0-25cm, 25-50cm, 50-75cm and 75-100cm, using a soil auger. Moisture content of the sample was found out by oven dry method. The difference in the moisture content before and after irrigation gave the water stored in the root zone. From the ratio of water stored in the root zone to the water delivered to the field, water application efficiency was found out.

Water storage efficiency

It is the ratio of water stored in the root zone during irrigation to the water needed prior to irrigation. It is expressed as

$$E_s = W_s \times 100/W_n$$

Where

E_s = water storage efficiency

W_s = Water stored in the root zone during irrigation

W_n = Water needed in the root zone prior to irrigation

This gives how completely the water needed prior to irrigation has been stored in the root zone during irrigation. In order to get the amount of water needed prior to irrigation, water content before irrigation and field capacity of the soil was found out. For finding out the field capacity the field was fully saturated and kept for 24hrs and the moisture content was measured after 24hrs from various depths. This gave the moisture content of the soil at field capacity. The difference in moisture content at field capacity and the moisture content prior to irrigation gave the amount of water needed prior to irrigation. Water storage efficiency becomes important when water supplies are limited or when excessive time is required to secure adequate penetration of water in to the soil.

Water conveyance efficiency

This is used to measure the efficiency of water conveyance system and is expressed as

$E_c = W_f \times 100/W_d$

Where

E_c = Water conveyance efficiency

W_f = Water delivered to the irrigated field

W_d = Water diverted from the source

As in the drip and sprinkler irrigation systems, water is conveyed through conduit pipes only frictional loss is likely to occur. So water conveyance loss was taken as negligible.

Operating pressure

Measurement of operating pressure was important as it influence other parameters like radius of throw and overlapping in sprinklers. A pressure gauge connected with a pitot tube was used to measure the pressure at the sprinkler nozzle.

Variation in operating pressure of the drip system is the main cause of variation in discharge at different points. So it is an important factor affecting the dripper uniformity. Operating pressure was measured by connecting the pressure gauge at various points in the lateral.

Operating pressure in basin irrigation was measured by connecting the pressure gauge at the outlet of the pump.

Volume of water applied

Quantity of irrigation water used by the farmer to irrigate coconut was measured manually to ascertain whether the farmer was irrigating palms with the recommended quantity of water. For drip irrigated plots this was measured as described by Bralts and Kesner (1982).

Quantity of irrigation water for sprinkler irrigation was measured by catch can method (Jarjuelo *et al.*, 1999). The same for basin irrigation was worked out by monitoring the discharge at sixteen locations in each plot.

Root zone area wetted

For effective irrigation, a minimum of 30% of the root zone area should be wetted in drip irrigation (Mathew *et al.*, 1999). Once the quantity of irrigation water is fixed for a crop only discharge rate and number of dripping points could be adjusted to obtain sufficient root zone area wetted (Oner and Demet, 2008). Top soil around the dripping point was removed and the area of root zone wetted from the dripping point was measured using a measuring tape for this purpose.

In sprinkler irrigation the whole field including the coconut basin gets wetted during irrigation. So there is no role for wetted diameter in sprinkler irrigation. In this irrigation actually the radius of throw is a measure of wetted diameter.

Since applied manually the entire coconut basin was getting wetted fairly in basin irrigation.

Number of dripping points

The present recommendation is to provide four dripping points in sandy loam (Mathew *et al.*, 1999) and laterite (Dhanapal *et al.*, 1995) soils and six dripping points in sandy soil (Maheswarappa *et al.*, 1997) for coconut to obtain a minimum of 30% of the root zone area to be wetted. Number of dripping points used per palm in the farmer's field was noted.

Discharge rate of drippers

Discharge rate of dripper is an important criterion which decides the horizontal and vertical movement of water from a dripping point. Normally more the discharge rate larger will be the horizontal movement of water and there by increasing the root zone area wetted (Maheswarappa *et al*, 1997; Mathew *et al*, 1999). If the discharge rate is more than the optimum level water will be wasted as surface runoff. Average discharge rate of drippers was measured in the farmers' field since it will directly affect the wetting pattern.

Location of emitter

Active root zone of coconut lies within 2m radius. Therefore, it is recommended to put the dripping point at

1m away from the palm. This would provide maximum wetted area within the root zone (Maheswarappa *et al.*, 2000). Distance from the palm where dripping point placed in the farmer's field was noted and it was compared with the optimum distance as per standard.

Spacing between two laterals as well as two sprinklers in a lateral was found out by measuring the distance between them. The spacing should be wisely selected in order to get proper overlapping which results in the uniform distribution of water. As mentioned earlier a flexible hose pipe was used in basin irrigation to irrigate coconut palms. Spacing was not significant in such a system.

Deep percolation

The rootzone depth of coconut is 1 m. Whatever water goes beyond this depth would be of not much use to the palm. Deep percolation could be avoided by carefully adjusting the discharge rate of emitter. It again depends on the soil type. In sandy soil vertical movement of water would be much more than horizontal movement. Whereas in clay soils it is in the reverse order at the beginning. Deep percolation was measured by taking soil samples using soil augurs at a depth of 1 m and analyzing it for soil moisture content.

Results and Discussion

Volume of water applied per palm per day

For coconut CPCRI recommends application of irrigation water @ 66 % of open pan evaporation for drip irrigation. With the prevailing climatic conditions of the study area this works out to be approx. 32 l of water per day per palm for coconut (Dhanapal *et al.*, 2004). The present study revealed that a majority of the farmers were irrigating their coconut palms with much more than the recommended quantity of water (Table 1).

Table 1. Volume of water applied per palm per day through drip irrigation

Volume of water applied per palm per day (l)	Frequency	Percent
<32	15	25.9
32	0	0
>32	43	74.1
Total	58	100.00

Many farmers adopted drip irrigation not because of water scarcity. Majority of the farmers believe that giving more water to coconut results in better yield.

In sprinkler irrigated fields also volume of water applied per palm was much more than actually required. It was five times than that of drip and two times than that of basin irrigation.

The same trend was observed in the case of basin irrigation. It was observed that the volume of water applied was more than the recommended amount, i.e. 200 lit per palm once in four days except in eight gardens.

Distribution uniformity

Efficiency of an irrigation system depends upon the degree of uniformity of water application. Distribution uniformity varied greatly (29.22-68.88 %) in different drip irrigated fields. Average distribution uniformity obtained by drip irrigation in the study is only 46 %. This shows the poor distribution of water among the dripping points. Clogging due to physical and chemical impurities is the main reason for this poor distribution uniformity. Another reason is the undulating topography prevailing in many of the gardens. As mentioned earlier, majority of the farmers use micro tube as dripper. Variation in water pressure affects the discharge rate of this type of dripper. When the water pressure increases in the laterals discharge rate of dripper also increases accordingly. Absolute emission uniformity of drip irrigation, another method of estimating the degree of uniformity of water application, also was worked out and confirmed the poor distribution uniformity. All the fields taken for study had poor emission uniformity (<70).

Though the average distribution uniformity obtained by sprinkler irrigation in the study is same (46 %) as that of drip irrigation, the range (12.7-68.61 %) varied much more than that of drip. This shows the poor distribution of water within the field. Clogging due to physical impurities (sand particles) and obstruction to the water jet due to intercrops and other vegetation are the main reasons for the poor distribution uniformity. Another reason is the undulating topography prevailing in many of the gardens.

In basin irrigated gardens all the farmers were doing irrigation manually. A hose pipe connected to an overhead tank or to the outlet of an electric/ diesel pump was used by farmers to irrigate the coconut basin. Most of them stay in the garden throughout the irrigation period. Because of that, they could apply water throughout the coconut basin. This is the reason for obtaining high distribution uniformity (90.33 %) in basin irrigation compared to other irrigations. The maximum, minimum and average values of distribution uniformity are given below. Variation in distribution uniformity (79.75-96.43 %) also is much less than that of other irrigations.

Storage efficiency

Storage efficiency is the ratio of water stored in the root zone during irrigation to the water needed prior to irrigation. This gives how completely the water needed prior to irrigation has been stored in the root zone during irrigation.

Storage efficiency varied from 36 % to near 100 % in drip irrigation with an average value of 56.35 %. Reason for 100 % storage efficiency is over irrigation. Majority of farmers provide much more water than the recommended amount. Though, this helps in replenishing the water deficit in the root zone, a good amount of water is being lost as deep percolation. Reason for the low storage efficiency is under irrigation. 26 % of the farmers provided less than the recommended amount of water. Water deficit in the root zone could not be replenished in such cases resulting in such low storage efficiency.

Variation in storage efficiency (56.47-97.32 %) obtained in sprinkler irrigated fields in the study was less than that of drip irrigation and the average value (72.42 %) was much better than that of drip irrigated fields. Maximum storage efficiency obtained was 97 %. Majority of the farmers apply much more than the recommended volume of water. This is the main reason for such high storage efficiency. Low storage efficiency observed in some of the plots was due to the poor distribution of water.

Variation (70.34-92.30 %) as well as the average (84.48 %) value of storage efficiency obtained in different basin irrigated fields was much better than other two other irrigation methods in the study. In basin irrigation the entire coconut basin was getting wet fairly uniformly, ie, high distribution efficiency. Because of this most of the water got stored in the root zone. This is the reason for getting high storage efficiency in basin irrigation.

Application efficiency

Water application efficiency is a measure of how efficiently water is applied to the field. It is the amount of water stored in the root zone of the plant out of the total water applied.

Application efficiency varied in the range of (12.14-76.61 %) in different drip irrigated fields with an average value of 43.77 %. In drip irrigation, maximum water application efficiency was observed in fields giving less water than the recommended amount. In such cases almost all the water applied gets stored in the root zone. Loss of water due to deep percolation is less in such cases. Over irrigation, application of more water than the recommended amount is the main reason for the poor application efficiency. Poor horizontal distribution of water in the coconut basin mainly due to less number of dripping points used is another reason for poor application efficiency. Application efficiency also reduced when the discharge rate was kept less than the recommended rate. In all these cases much of the water applied lost as deep percolation and leads to poor application efficiency.

Application efficiency varied from 19.43 % to 85.32 % in sprinkler irrigated fields with an average value of 48.48 %. Over irrigation, application of more water than the recommended amount is the main reason for the poor application efficiency. Most of the water applied was lost as deep percolation.

Though the distribution efficiency obtained was very high in basin irrigation, the application efficiency obtained (80.02 %) was slightly less mainly because of the deep percolation of some amount of water applied. Variation in application efficiency (72.45-87.20 %) of basin irrigation was much less than that of the other two irrigation methods.

Water conveyance efficiency

Water conveyance efficiency is a measure of how efficiently water is conveyed from the source to the palm. As in the case of drip, sprinkler and basin irrigation systems, water is conveyed through conduit pipes. Loss of water during conveyance was not observed in any of the coconut gardens except for the sporadic breakage reported by some of the farmers. So water conveyance loss was taken as negligible.

Percolation loss

Deep percolation was occurring in most of the irrigated fields taken for the study. However, quantification of the same was not attempted. Among the irrigation methods studied loss of water due to deep percolation was least in basin irrigated fields. All the basin irrigated gardens were irrigated manually and a person used to be present throughout the irrigation in majority of the cases. He could apply water within the entire basin fairly uniformly thereby reducing deep percolation and achieving very good distribution efficiency.

Water source

Irrigation water source used in three irrigation systems also varied. Different water sources used in drip irrigated fields is given in Table 2.

It was observed that majority of farmers used either open well or tube well as the source of water for drip irrigation.

Table 2. Type of water source of drip irrigation system

Water source	Coconut garden	
	Frequency	Per cent
Open well	36	62.1
Bore well	19	32.7
Open well & Bore well	0	0
Open well & River	3	5.2
River	0	0

Out of the 62 sprinkler irrigated fields evaluated except in three cases the water source was tube well. It was noticed that only farmers having enough water were using sprinkler irrigation. In basin irrigated fields water source used for irrigation was mostly open well.

Type of filter

Type of filters used in the drip irrigation to clean the irrigation water is given in Table 3.

Table 3. Type of filters used in drip irrigation

Type of filter	Coconut garden	
	Frequency	Per cent
Nil	16	27.6
Wire mesh filter	40	69
Sand filter	2	3.4
Total	58	100

Majority of the drip irrigation units installed in farmers' field was having wire mesh filter to clean the irrigation water. Even after providing a filter some farmers faced the problem of clogging of emitters, especially those who were using drippers other then microtube. No farmer of the sprinkler irrigated coconut garden was using filter. Though the tube well water is of good quality some farmers face the problem of clogging of sprinkler head due to sand particles.

None of the farmers using basin irrigation used any type of filter. Since all were irrigating coconut manually using a flexible pipe (hose pipe), it was not necessary to provide a filter.

Clogging of emitters

Efficiency of drippers to resist clogging was observed to be high in micro tube compared to pressure compensating and non pressure compensating drippers used by farmers. A study conducted at CPCRI to find out the comparative efficiency of various dripping points in reducing clogging also revealed that the efficiency of drippers to resist clogging increases in the order Micro tube > Pressure compensating > Non pressure compensating & Tap type dripper. The present study confirms this finding.

Clogging of sprinkler head due to sand particles was observed in few of the sprinkler irrigated fields. However, clogging of sprinkler heads was rare since the irrigation water quality was good. Clogging was not observed in basin irrigation.

Water supply

The recommended method of water supply in drip and sprinkler irrigation is by direct pumping, as it provides a uniform and required operating pressure and discharge. The pattern followed by drip irrigated farmers is furnished in Table 4.

Table 4. Method of water supply in drip irrigation

Method of water supply	Frequency	Percent
Direct pumping	8	13.8
Through over head tank	50	86.2
Total	58	100.0

It was observed that most of the farmers provided water for drip system through overhead tanks. Majority were using overhead water tank used for domestic water supply for irrigation also. This way they could avoid the additional cost involved in having a separate tank for irrigation.

Water supply was by direct pumping in all the sprinkler irrigated fields since they get the required head by this way. To get specified head for sprinkler irrigation, an over head tank needs to be very high and would be prohibitively costly for an ordinary coconut farmer.

In basin irrigation also water supply was through direct pumping in all the cases.

Operating pressure

Operating pressure of the three irrigation systems varied very much between plots. In drip irrigation the operating pressure was found to be varying from 0.1 to 1.1kg/cm^2. Main reason for the low operating pressure is most of the farmers use an overhead tank for irrigation. Some of them use domestic water tank for irrigation also. Domestic water tank is usually kept at a low height of 4m.

Operating pressure at the orifice of the sprinkler was noted using a pitot tube fabricated for the purpose. Operating pressure was found to be varying from 0.4 to 1kg/cm^2. This wide variation is mainly because of the undulating topography prevailing in many of the farms observed. Operating pressure in basin irrigated fields also varied from 0.4 to 1kg/cm^2.

Radius of throw

Only drippers were used as emitter in drip irrigation for providing water. None of the farmers used other type of emitters such as micro sprinklers, micro jets etc. Therefore, radius of throw of drippers was not relevant.

Radius of throw of sprinkler heads varied from 7.5m to 22m with an average of 13.5m. Difference in radius of throw was mainly due the size and make of the sprinkler heads used by the farmers. Undulating topography also played an important role in the difference in radius of throw observed within the plot.

All the basin irrigated plots were irrigated manually using water conveyed through a flexible pipe (hose pipe). There fore, radius of throw is not relevant here also.

Spacing/ Location of emitter

Active root zone of coconut lies within 2m radius. Therefore, it is recommended to put the dripping point at 1m away from the palm. This would provide maximum wetted area within the root zone.

However, the present study showed that in 69 per cent of the coconut gardens distance of dripping point from tree trunk was less than the recommended distance. Most of the farmers have a wrong notion that keeping the dripping point closer to the tree trunk is better. It is also noticed that no farmer has kept the dripping point farther than the recommended distance.

Spacing of sprinklers was not uniform and varied widely within the coconut garden. Spacing observed was in the range of 14-20m with an average value of 16m.

As mentioned earlier a flexible hose pipe was used in basin irrigation to irrigate coconut palms. Spacing was not significant in such a system.

Wetted diameter

As per the guidelines for effective irrigation through drip system, a minimum of 30% of the root zone area should be wetted in drip irrigation. Results of the study furnished in Table 5 show that except in four fields the recommended level of root zone area of palms was not getting wetted. Providing less than the recommended number of dripping points and keeping the dripping point at less than 1m are the major reasons for not getting sufficient wetted root zone.

Table 5. Root zone area wetted through drip irrigation

Root zone area wetted (per cent)	Frequency	Percent
<30	54	93.1
>30	4	6.9
Total	58	100.00

In sprinkler irrigation the whole basin gets wetted during irrigation. So there is no role for wetted diameter in sprinkler irrigation. In this irrigation actually the radius of throw is a measure of wetted diameter.

Since applied manually the entire coconut basin was getting wetted fairly in basin irrigation. Among the irrigation methods coconut basins of basin irrigated fields got maximum wetted area with uniform distribution of water within the basin.

Number of emitters

The present recommendation is to provide four dripping points in sandy loam (Mathew *et al.*, 1999) and laterite (Dhanapal *et al.*, 1995) soils and six dripping points in sandy soil (Maheswarappa *et al.*, 1997) for coconut to obtain a minimum of 30 per cent of the root zone area to be wetted. But the results showed that only 30 per cent of coconut gardens were having the recommended number of dripping points per palm. More than 60 per cent of the gardens were having less than the recommended number of dripping points per palm.

Effect of number of drippers on root zone area wetted is shown in Fig.1. It was observed that root zone area wetted increases with number of dripping points. Providing more than the required quantity of water through less than the required number of dripping point lead to loss of water through deep percolation and thereby low irrigation application efficiency.

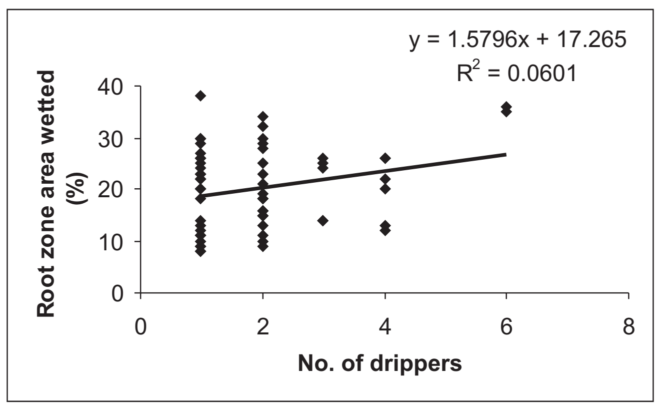

Fig.1. Effect of no. of drippers on root zone area wetted

Number of emitter has no relevance to basin and sprinkler irrigation since the entire coconut basin gets wetted in both the irrigations and hence the same was ignored.

Placement of emitters

Studies conducted at CPCRI showed that applying water subsurface helps to reduce evaporation from soil surface (Dhanapal *et al.*, 1995, Jose *et al.*, 2008). Results (Table 6) showed that most of the farmers under the study were keeping the dripping points on surface itself. Surface placement of dripping points resulted in loss of water through evaporation. These points to the need to make efforts to create awareness among the farmers adopting drip irrigation system about the need and importance of proper placement of drippers, i.e., subsurface placement of drippers to minimize the evaporation loss.

Table 6. Placement of dripping points in the drip irrigation

Placement of drippers	Frequency	Percent
Surface	55	94.8
Sub surface	3	5.2
Total	58	100

However, sub surface application of water is not possible in basin and sprinkler irrigations.

Type of emitters used

The present study revealed that a vast majority of the farmers were using micro tube as drippers in their drip system (Table 7). Pressure compensating type dripper which is the ideal dripper in an undulating terrain was used only by 30 percent of the farmers. The pressure compensating type of dripper is much costlier than micro tube. This was the main reason for the low rate of adoption of this type of dripper. However, micro tube also provided satisfactory distribution efficiency. Moreover clogging of dripper, a major problem in drip irrigation was the lowest in micro tube.

Table 7. Type of drippers used in drip irrigation

Type of drippers	Frequency	Percent
Micro tube	37	63.8
Pressure compensating	18	31.0
Non pressure compensating	3	5.2
Total	58	100

Only one type of sprinkler head, rotating type, was used by all the coconut farmers in the study. However, radius of throw of sprinkler heads varied. Similarly, basin irrigation was done by a flexible hose pipe by all the farmers. However, size of the same and thereby discharge varied.

Soil type

Soil types predominant in the study area were sandy soil in the coastal area, sandy loam soil and laterite soil in the mid land and up land. All the three irrigation systems and rain fed cultivation were practiced by coconut farmers in all these soil types.

Reasons for low wetted area

Wetted area in the coconut basin under drip irrigation depends on (1) number of dripping points per palm, (2) spacing of drippers, and (3) discharge rate of drippers.

The present recommendation is to provide four dripping points in sandy loam (Mathew *et al.*, 1999) and laterite (Dhanapal *et al.*, 1995) soils and six dripping points in sandy soil (Maheswarappa *et al.*, 1997) for coconut to obtain a minimum of 30 per cent of the root zone area wetted. It was also stressed by these workers to operate the drippers at a higher discharge rate of 4 to 6 litres per hour. Operating drippers at a higher discharge rate reduces the chance of clogging (Padmakumari and Sivanapan, 1985). The drippers need to be placed equidistant around the palm at a distance of 1 m away from it.

The study showed that only 34 per cent of coconut gardens in sandy loam and laterite soils were having the recommended number of dripping points per palm. None of the coconut gardens grown in sandy soil was having the recommended number of dripping points. It is also required to keep the dripping points equidistant around the palm at a distance of 1 m away from it in order to obtain maximum wetted soil within the root zone. But from the results obtained, it can be seen that in more than 90 per cent of the coconut gardens distance of dripping points from tree trunk was less than the recommended distance and also the placement not equidistant. This was the single most important parameter that reduced the wetted area within the rootzone. It is evident from the soil moisture measurements made at a depth of 1 m that considerable amount of water was lost as deep percolation. However, the amount of percolated water beyond rootzone could not be quantified due to practical difficulty in taking soil samples. Discharge rate of drippers was kept at 4 lit./ hr or more in all the plots.

Experiments at CPCRI proved that applying water subsurface would help to reduce evaporation from soil surface. However, results showed that all the farmers under study except one coconut farmer were keeping the dripping points on surface itself. Surface placement of dripping points definitely resulted in loss of water through evaporation. Sub surface placement also helps in preventing dislocation of emitters. This points to the need to make efforts to create awareness among the farmers adopting drip irrigation system about the need and importance of proper placement of emitters.

Conclusion

Taking in to account different indicators of irrigation efficiency it can reasonably be concluded that basin irrigation performs better than drip and sprinkler irrigation systems. The study also reveals the scope for improving the irrigation efficiency in coconut garden through proper adoption of recommended practices. Hence, it is necessary that appropriate educational programs are essential to create awareness among coconut gardens and other stakeholders.

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