COMPARATIVE EVALUATION OF DIFFERENT MICRO IRRIGATION METHODS IN CROP GEOMETRY OF BANANA

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PROJECT REPORT

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DECLARATION

We here by declare that this project report entitled "**Comparative Evaluation of Different Micro Irrigation Methods in Crop Geometry of Banana**" is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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CERTIFICATE

Certified that this project report entitled "**Comparative Evaluation of Different Micro Irrigation Methods in Crop Geometry of Banana**" is a record of project work done independently by **Assiya Lebeeha K. A., Bhavya .P.R** and **Sreekanth .K.S** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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Assiya Lebeeha .K.A.

Bhavya .P.R.

Sreekanth .K.S.

DEDICATED

TO

OUR LOVING PARENTS

AND

TEACHERS

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SYMBOLS AND ABBREVIATIONS

%	percentage
&	and
/	per
ASAE	American Society of Agricultural Engineers
B/C ratio	Benefit-Cost ratio
BIS	Bureau of Indian Standard
cm	centimeter
cm^2	centimeter square
COV	Coefficient Of Variation
CPE	Cumulative Pan Evaporation
CUC	Christiansen's Uniformity Coefficient
DAP	Days After Planting
DC	Distribution Characteristic
DC	Distribution Coefficient
et al.	and other people
g	gram
ha	hectares
hp	horse power
kg	kilogram
kg/ha	kilogram per hectare
kg/ha-cm	kilogram per hectare centimeter
kPa	kilo Pascal
lph	litres per hour
lps	litres per second
m	meter
m^2	meter square
m^3	meter cube

min	minutes
ml	milliliter
mm	millimeter
mm/hr	millimeter per hour
MSL	Mean Sea Level
no.	number
ºC	Degree Centigrade
ºE	Degree East
ºN	Degree North
PFDC	Precision Farming Development Center
q	quintal
q/ha	quintal per hectare
USA	United States of America

INTRODUCTION

INTRODUCTION

Agriculture is the science or art of cultivating the soil, growing and harvesting crops, and raising livestock. The word agriculture comes from the Latin word ‘ager’ meaning field and ‘cultera’ meaning cultivation. Agriculture has no simple, single origin. The art of making land more productive is practiced throughout the world.

Over the years Agricultural Engineering has become an increasingly important part of the technical foundation for supporting agricultural productivity well above the subsistence level.

1.1 Fruit production

Fruit production occupies prime position in the Horticulture sector. A large variety of fruits are grown in India among them mango, banana, citrus, guava, grapes, pineapple and apple are the major ones. Apart from these papaya, sapota, annona, phalse, jackfruit, ber, pomegranate in tropical and subtropical groups, and peach, peer, almond, walnut, apricot and strawberry in the temperate group are also grown in a sizeable area. Owing to the increasing demand both in domestic and foreign markets, fruit production is gaining more and more commercial importance in recent years. Therefore, the area under fruit crops is in rapid increase. Almost 25,000-30,000 ha area is added annually through intervention of the Central Government alone. Another about one lakh hectare is planned to be added during the Nineth plan period. Besides, State Governments have their own programmes to bring in more area under fruit crops. Presently, about 3.7 million ha area is under fruit crops.

Like all agricultural crops, fruit crops require essential natural resources viz land, water and sunlight, of which water is a crucial input. About 1.2 million ha of fruit crops is estimated to be under conventional method of irrigation. Although water is a renewable resource, stress in the availability of water to meet the growing demand of the rising population has been increasing. Therefore, efforts have been on for employing more efficient methods of irrigation like drip/micro irrigation. Since most of the fruit crops are planted on rows, they are ideally suited for micro irrigation. Programmes have been initiated to promote micro irrigation in a large way in the Horticulture sector on an average of about 30,000 ha area is being brought under the same annually under Horticultural crops. In all, about 0.3 million ha area has been brought under micro irrigation till 1998-99 of which, about 0.17 million ha is under fruit crops. However, compared to the total area under fruit crops, there is a need to cover more area by micro irrigation. (*Samuel, J.C, 1999)*

1.2 Banana production

Banana is the third important fruit crop covering an area of nearly 0.35 million ha. This area is gradually increasing because of higher productivity and remunerative prices. The crop is moisture loving and responds well to applied water. Because of its shallow root system, excess water applied invariably is wasted due to percolation losses. Irrigation scheduling with tensiometer at -45 kPa metric potential at 15 cm depth is optimum in Robusta variety and the total evapotranspiration of the crop was around 1,600mm during the study. Drip irrigation with 80% replenishment of evaporation could bring about nearly 25% saving in irrigation water in Robusta variety of banana. (*Srinivas, K, 1999)*

1.3 Irrigation in banana

Being a succulent plant, banana requires high amount of water which shall be met either by well distributed rainfall or through irrigation. Any short fall occurred has to be met by irrigation to reach the potential yield. Need for irrigation is also determined by the cultivar and soil type. Different types of irrigation following in banana are:

1.3.1 Flood irrigation

In garden land cultivation, flood irrigation is normally followed. In this method, beds of 5×5 m or more are made depending upon gradient or slope which are connected by main and sub channel. Irrigation is done once in a week in summer and once in a fortnight in winter. Many time flooding results in excessive application of water.

1.3.2 Trench irrigation

It is a feature of wet land banana cultivation. In this system trenches after two rows of banana serve the irrigation channel. Water is allowed to stand in trenches and optimum soil moisture is maintained in beds through horizontal percolation and with growing age of plants trenches are also deepened. In rainy season, the same trenches are deepened 45-60 per cent to drain out excess of water. This system is followed in places where water table is high.

1.3.3 Drip irrigation system

It is an advanced method of irrigation by providing precise and measured quantities of water directly to the root zone. Principle involves supply of water drop by drop through plastic emitters or drippers through a lower pressure delivery system. The system requires a pump with energy source, filters, main and sub main lines, laterals or drippers with other control equipments. Research reveals 100-200 per cent increase in yield, 45-50 per cent saving in irrigation water and 30 per cent reduced requirement of nitrogenous fertilizers. It has other advantages like, reduced crop growth period, higher water use efficiency, utilization of even saline and alkaline water etc. This system of irrigation is increasingly becoming popular in the region where water is scarce.

1.3.4 Micro sprinklers

Micro sprinklers have originally been used for under tree irrigation. But, later on, it was found to be useful for close growing crops, row crops, nurseries, green houses etc, also. In orchards, it is used for single trees, in the form of micro sprayers . But if it is used for closely-spaced crops like vegetables, it would reduce number of laterals as well as emission devices. The size of laterals may have to be slightly increased costing a little more per unit length. Similarly, a single micro sprinkler would cost more than an emitter but the overall installation would be costing less than the drip systems. Additionally, micro sprinklers can use less clean water than emitters, without clogging. They may, therefore, not require costly media filters as required by normal drip system. However, they may, require slightly more discharge than drip systems. The micro sprinklers may have one disadvantage that it may be non-feasible to apply fertilizers with it for some crops with sensitive foliage. Also, it may have to be used with caution for some crops during the time of its flowering. Nevertheless, as a whole, this system seems to be more promising for future applications. Thus, it may be pointed out that there has been an increasing trend in the use of micro sprinklers in U.S.A, Spain, Mexico, Japan, France, Thailand, Columbia, Cyprus and Italy. (*Chauhan, H.S, 1991*)

Under these circumstances, this study has been undertaken with the following objectives.

OBJECTIVES

1. **To evaluate different irrigation methods in banana.**
2. **To study the performance of banana under different irrigation method.**
3. **To compare the moisture distribution pattern of micro sprinklers under different pressure.**
4. **To determine the performance indices of different micro irrigation systems.**
5. **To determine the benefit cost ratio for different irrigation methods.**

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1 Origin and agronomic aspects

Banana prefers tropical humid low lands and is grown from the sea level to 1000 m above MSL. It can also be grown at elevations up to 1200 m, but at higher elevations growth is poor. Optimum temperature is 27°C. Soils with good fertility and assured supply of moisture are best suited.

2.1.1. Season

Rain fed crop	:	April-May
Irrigated crop	:	August-September

Adjust planting season depending upon local conditions. Avoid periods of heavy monsoon and severe summer for planting. Adjust the time of planting so as to avoid high temperature and drought at the time of emergence of bunches (7-8 months after planting).

2.1.2. Varieties

Nendran (clones)	:	Nedunendran, Zanbiar, Chengalikodan
Table varieties	:	Monsmarie, Robusta, Giant Governor, Dwarf Cavendish
Culinary varieties	:	Monthan, Batheesa, Nendrapadathy

2.1.3. Preparation of Land

Prepare the field by ploughing or digging and dig pits for planting. Size of pits depends upon soil type, water table and variety. In general, pits size of 50x50x50 cm is recommended. In low-lying areas, take mounds for planting suckers.

2.1.4. Selection of suckers

Select 3-4 month old disease free sword suckers from healthy clumps. In the case of Nendran variety, cut back pseudo stem to a length of 25-20 cm from corm and remove old roots. The rhizomes are to be smeared with cow dung solution and ash and dried in the sun for about 3-4 days and stored in shade up to 15 days before planting.

2.1.5. Spacing

Spacing may be provided as shown in table1.

Table 1. Spacing of common varieties of banana

Variety	***Spacing, m***	***Suckers***
Poovan	2.1×2.1	2260
Nendran	2.0×2.0	2260
Palayankodan	2.1×2.1	2260
Monthan	2.1×2.1	2260
Robusta	2.4×1.8	1730

2.1.6. Planting

Plant suckers upright in the centre of pits with 5 cm pseudo stem remaining above soil level. Press soil around the suckers to avoid hollow air spaces.

2.1.7. Mannuaring

1. Apply compost, cattle manure or green leaves at the rate of 10 kg/plant at the time of planting.
2. Apply N**:** P_2O_5 : K_2O at the following dose (g/plant/year).

Nendran (irrigated)	:	190:115:300
Palayankodan (rain fed)	:	100:200:400
Other varieties depending upon		
Soil fertility level	:	160-200:160-200:320-400

For Nendran, apply the fertilizer in six split doses which will be beneficial to improve the finger size and bunch weight, provided the farmers can afford the cost of application.

2.1.8. Irrigation

1. During summer months, irrigate once in two days at the rate of 40 lit/plant.
2. Ensure good drainage and prevent water logging.
3. About 6-10 irrigation per crop may be given depending up on soil conditions.

2.1.9. Weed Control

During early stages, complete control of weeds could be obtained by raising cowpea in the inter spaces. In gardens where this is not possible, pre-emergence weedicide application viz diuron 1.5 kg/ha or oxifluorfen 0.2 kg/ ha is effective. Post-emerging weeds could be controlled by the application of paraquat 0.4kg/ha or glyphosate 0.4kg/ha. If hand weeding is resorted to, give 4-5 surface diggings depending on weed growth. Avoid deep digging. Do not disturb soil after plants start producing bunches. If green manure crop is grown, weeding operations can be reduced 1-2 diggings. (*Package of practices recommendations: crops, Kerala Agricultural University, Thrissur)*

2.2. Micro irrigation

Micro irrigation is well suited for fruit crops but it has not been fully exploited. In India, the area of irrigation of fruit crops is only about 30% and the average productivity is very minimum. The fruits are not even sufficient. There is a tremendous scope in extending the area of irrigation for fruit crops. Drip irrigation can increase productivity and also the quality of fruits. Therefore, it is planned to bring at least 2 million ha under micro irrigation by the year 2020/25. This will not only meet the demand of population and the same time, it will fetch the much required foreign exchange by exporting fruits. *(Sivanappan, R.K, 1995)*

Coconut, Arecanut and Oil palm are important palms that are grown in India. In coconut, commonly used irrigation systems are flood, basin, sprinkler irrigation of perfo-spray and drip irrigation. In Arecanut, commonly used systems in addition to the above is storing water in irrigation channels by bunding and allowing water to percolate. In oil palm, basin irrigation is most common while drip and micro irrigation are gaining popularity.

Research conducted on different systems of irrigation has revealed that drip irrigation can help in economizing water use in all the palms in addition to another benefit such as less weed problem and less requirement of manual labour. These advantages certainly over weigh the initial establishment cost of drip irrigation system. Due to the introduction of subsidy to install micro irrigation system, it is gaining popularity among palm growers in different regions. (*Rethinam, P and Reddy, V.M, 1999)*

Another study reveals the use of micro sprinkler for cooling plants to enhance the quantity and quality of production or for cooling soil for improved germination and seedling production. Effect of operating pressure, duration and uniformity coefficient on decrease in temperature and increase in relative humidity has been studied. A cyclic sprinkling of about 15-30 minutes at low operative pressure of a micro sprinkler system designed for better uniformity coefficient was found efficient for environmental control. (*Singh, R.P, Sudeep singh, Upendra singh, 1999)*

2.2.1. Combined micro irrigation

Field experiments were conducted to investigate the effect of micro sprinkler plus drip, micro sprinkler, surface plus drip and surface irrigation on the bio metric characteristic, yield and water economy of sweet lime. Results indicated that there was a significant increase in the vegetative growth of the plants irrigated through different micro irrigation techniques compared to surface methods of irrigations. Total yields of sweet lime obtained after 2 years of planting was 7.04, 6.16, 4.48 and 3.92 q/ha for micro sprinkler plus drip, micro sprinkler, surface plus drip and surface irrigations respectively, resulting in higher yields of 79.6, 57.1 and 14.3% for micro sprinkler plus drip, micro sprinkler and surface plus drip respectively, over surface irrigation. Saving of water achieved over surface irrigation was maximum (28.14%) in micro sprinkler plus drip followed by micro sprinkler irrigation (19.94%) and minimum of 4.11% with surface plus drip irrigation. The higher water use efficiency of 3.95 kg/ha-cm was recorded from the plants irrigated through micro sprinkler plus drip followed by 3.34 kg/ha-cm with micro sprinkler, 2.28 kg/ha-cm with surface plus drip and minimum of 1.96 kg/ha-cm in case of surface irrigation. Substantial saving of water (31 times) was achieved by irrigating the plants through drippers instead of micro sprinkler during the lean and gap periods of inter crop. (*Manjunatha, M.V, Shukla, K.N, and Chauhan, H.S, 1998)*

2.2.2. Economic feasibility of micro irrigation

Economic feasibility of micro irrigation systems for various vegetables, such as Cabbage, Potato, Brinjal, Chilli, Cauliflower and tomato were worked out for Nainital tarai region of Uttar Pradesh, India. The system cost is maximum for drip emitters due to more number of emission devices and laterals and minimum for micro sprinklers. The cost of cultivation is maximum for surface irrigation and minimum for drip emitters and drip micro tubes. The net seasonal income obtained per hectare area of cabbage cultivation was highest for drip micro tubes followed by drip emitter, micro sprinkler and lowest for surface irrigation. (*Manjunatha, M.V, Shukla, K.N, Chauhan,H.S, Singh,P.K. and Rameshwar Singh,1995)*

2.2.3. Drop size distribution and water application efficiency

Drop size distribution, uniformity coefficient and water application profile of micro sprinklers were studied by installing the system in an enclosed area to ensure no wind condition. The drop size distribution was measured by flour method. The uniformity coefficient was measured by Christiansen’s formula. The water application profile uses measurements by arrangement of catch cans. The drop size distribution and uniformity coefficient followed almost the same trend as rotary sprinklers. The water application profile was not of continuous type as only 50% of the diameter of throw received sprinkled water. (*Singh, R.P, Singh, V.P, Naipali Babu, 1990)*

2.3. Drip irrigation

Investigations were carried out to study the growth and productivity of banana under drip and ring basin irrigation in combination of black plastic mulch at different levels of irrigation at the experiment farm, Department of Agricultural and Food Engineering, Indian Institute of Technology, Kharagpur, West Bengal. The highest yield was recorded under drip irrigation with black plastic mulch as compared to other treatments. Net profit per mm water used and water use efficiency were recorded highest under drip irrigation with mulch. (*Jiwari, K.N, Mal, P.K, Chattopadhyay, A, Singh, R.M, Kannan, N, 1992)*

2.3.1. Estimation of net irrigation

Net irrigation requirement of banana crop was estimated by modified Penmann method using historical climatology data collected from distinctly two sub regions viz. scarcity and assured rainfall of Marathwada geographical region of Maharashtra for the purpose of scheduling of irrigation using drip system. Results revealed that for a water scarce area, NIR for drip system worked out to be 1328 mm as against 1251 mm for assured rainfall area for a July planted Banana crop. (*Sonune, S.P, Palaskar, M.S, 1992*)

2.4. Effects on biometric characteristics and yield

Field experiments were conducted in 240 square meter area from February to July 1993 at GBPUAT, Pantnagar (India), to study the performance of micro sprinkler, drip micro tube, drip emitter and surface methods of irrigation on bio metric yield of Bottle gourd. The sight is located at 243.8m altitude, 29°N latitude and 79.3°E longitudes in humid subtropical climate. The soil is sandy loam. The crop was planted on beds with 1.0m x 1.0m plant-to-plant and row-to-row spacing in a triangular pattern. The study indicated that the maximum length of vine was achieved in drip micro tube and minimum in micro sprinkler irrigation and found statistically significant in different methods of irrigation. The study also showed that the increasing number of branches in different micro irrigated treatments over surface was 17.48, 6.63 and 2.74% for drip micro tube, drip emitter and micro sprinkler respectively. The mean leaf area of bottle gourd were 267.25, 261.75, 261.50 and 248.50 cm^2 for drip micro tube, drip emitter, surface and micro sprinkler methods of irrigation respectively. These were found statistically insignificant.
(*Singh, K.L, Chauhan, H.S, Singh, P.K and Shukla, K.N, 1993)*

The result of field experiment conducted at Dr. Panjsbrao, Deshmukh Krishi Vidhyapeeth, Akola on potato variety Kufri Lavakar under different irrigation systems during 1993-94 showed a significant increase in tuber yield and water use efficiency was recorded in drip irrigation. The drip system recorded water use efficiency of 22.42 q/ha-cm with saving of water by 35.23%. There was increase in yield by 28.56% in drip system over furrow irrigation and was followed by broad base furrow, alternate skip furrow and skip furrow irrigation. *(Jadhav, S.N, Awari, H.W, Gore, A.K, 1994)*

The saving of irrigation water (36.9%) along with increase in potato yields (25.1%) were recorded in micro sprinkler irrigation compared to furrow irrigation. Various growth and yield parameters registered a significant increase in micro sprinkler irrigation compared to furrow irrigation. Better quality produce was also observed through micro sprinkler irrigation. Significant increase in number of stolons, number of tubes and tuber weight/plant compared to furrow irrigated plots. Larger sized potato tubers were more in micro sprinkler irrigation compared to furrow irrigation. The net saving of water achieved through micro sprinkler irrigation was 36.9% compared to furrow irrigation.

(Manjunath, M.V, Shukla, K.N and Chauhan, H.S, 1999).

A field experiment was conducted on chilli variety Phule-suryamukhi under micro sprinkler irrigation system with different irrigation level treatments during 1996-97. A non-significant effect was observed for consumptive use efficiency and yield of dry red chilli among the treatments. The maximum yield was recorded in three days irrigation interval treatment combination of five days irrigation interval with 0.7 CPE level. Also, the consumptive use efficiency was recorded highest in treatment of four days irrigation interval with 0.7 CPE level. *(Jadhav, S.N, Awari, H.W, Gore, A.K, 1997)*

2.5. Performance evaluation

In a purely volumetric sense, the efficiency of the system should be determined as the ratio of the water used by the plant to the water input. While the ultimate volumetric output of the irrigation system is the water used by the plant, the output product from the whole farming system is commonly viewed as the marketable crop of economic returns. While it is possible to argue that the efficiency of water should not be defined in terms of crop yield produced or value obtained, such gross indicators are of most practical interest to commercial irrigators. *(Dalton and Raine, 2000)*

Since irrigation uniformity is an important component of the evaluation of in–field performance and the determination of application efficiency often involves the crop yield produced or value obtained at the farm level; the performance of single non-overlapping micro-sprinkler systems can be evaluated on the basis of irrigation uniformity measures, in a purely technical sense. The performance of micro-irrigation is heavily influenced by the uniformity of application. Since the uniformity of distribution of irrigation water applied by a micro-sprinkler is the primary factor that determines the application efficiency, a measure of the distribution uniformity can better describe the performance of the system.

2.5.1. Catch-can test

The technique of catch-can testing is the suitable method for the performance evaluation of spray-type irrigation systems. ASAE (1991), ASAE (1997) and BIS (1987 a, b) describe the general procedure of catch-can testing and other standard methods of testing of sprinkler systems.

The performance of micro-sprinkler systems has been assessed commonly using catch-can methods with the cans placed in full wetted area or part (one quarter) of the wetted circle *(Boman, 1989; Pandey et al., 1995 b; Post et al., 1985).*

2.5.2. Performance indicators

A large number of indices for the assessment of irrigation performance have been proposed. Willardson (1972) stated that at least 20 definitions of irrigation efficiency existed at that time.

It is difficult to adequately evaluate irrigation performance using a single parameter. Hart (1972) suggests that it is necessary to use three efficiency terms and one distribution uniformity term to adequately describe the hydraulic performance of an in-field irrigation system. However, Walker (1993) used two efficiency and two uniformity indices while Connellan (1994) used only one efficiency and one uniformity term. At the system or whole farm level, a range of performance parameters may be appropriate depending on the spatial and temporal boundary conditions established for the evaluation (Dalton and Raine, 2000). Many irrigation workers and manufacturers of irrigation equipments use only a single term.

Different performance indicators (dimensionless coefficients) are used to describe the individual performance of micro-sprinkler. A wide range of irrigation uniformity coefficients are commonly used in performance evaluation (Jensen, 1983). The different coefficients and methods used for the evaluation of the performance of micro-sprinkler are Uniformity Coefficient, (UC), Distribution Uniformity (DU), Coefficient Of Variation (COV), Distribution Characteristic (DC), Distribution pattern (or densogram) and Scheduling Coefficient (SC).

2.5.2.1. Uniformity Coefficient

One of the basic measures of any irrigation system's performance is Christiansen's (1942) uniformity coefficient, CUC. Christiansen defined the uniformity coefficient as,

CUC = 1 – (D/M); where D is the average absolute deviation of irrigation amounts, and M is the average irrigation amount.

Although some modifications are also suggested to this relation, CUC is still used as a powerful tool for evaluating the performance of irrigation systems. The modification suggested (which incorporate the standard deviation of the irrigation amounts) are UCW and UCH.

UCW = 1 – (S/M) and

UCH = 1 – (0.798 S/M); where S in the standard deviation of irrigation amounts.

One of the limitations of the CUC calculation is that it treats under-watering and over watering the same.

2.5.2.2. Coefficient of Variation

The coefficient of variation, COV of application depths for a particular emitter is calculated by dividing the standard deviation of the depths by the mean of the depths. Since COV is a measure of the deviation of individual depths compared to the average depth, higher values of COV describe poor performance of the system and vice versa. COV is expressed as a percentage.

Boman (1989) evaluated several micro-irrigation emitters to determine their uniformity of distribution. The coefficient of variation of catch depths was selected as the primary performance indicator for the study. The author states that the COV is independent of the scale of measurement, and thus allows dimensionless comparison of variability for emitters with different flow rates. The COV values less than 100 can be considered as good water distribution and values over 200 indicate patterns that have a large portion of the effective area that receive no water. These high COV's may also signify that the pattern has areas with very high application depths relative to the mean.

2.5.2.3. Distribution Characteristic

Unlike impact sprinklers, micro-irrigation emitters generally are located in the field with non-overlapping patterns on widely spaced plants. Merriam and Keller's (1978) distribution characteristic (DC) is the standard method for evaluation for non-overlapping sprinklers. The DC is defined as the ratio of the area that receives more than half of the average application to the total wetted area, expressed as a percentage. The authors suggested that DC value greater than 50% are probably satisfactory and that very good patterns result with DC values greater than 66%.Although DC is the standard method for evaluation for non-overlapping sprinklers, other methods are also used either singly or in combination with one another. Post (1986) recommended using additional performance indicators in addition to DC in order to better characterise the emitter performance. The coefficient of variation was the indicator suggested by him.

2.5.2.4. Distribution pattern

The distribution pattern or spray coverage pattern is formed by a collection of curves (isograms) plotted by connecting the interpolated points of equal application rates within the wetted area. This gives a rough idea of how the emitter applies water to the irrigated area. A good emitter should produce circular isograms of decreasing application rates from centre to outer perimeter of the wetted area.

Christiansen (1942) was probably the first to point out the significance of distribution pattern in assessing the performance. The distribution pattern of a sprinkler gives water application rates (or depths) as a function of the radial distance from the sprinkler. The distribution pattern is affected by the combination of nozzle and pressure as well as the sprinkler model itself.

The 'densogram' is a modification to the distribution pattern. This involves the shading technique to represent the varying application rates. The densogram gives a good visual impression of distribution of irrigation water (as well as overall uniformity of application); it does not provide quantitative way to actually measure the uniformity.

A non-quantitative way to look at the wetted area is to have it graphically displayed using a shading technique. This process transforms the actual catch values into various intensities of shades. The dot matrix printer shading technique used by Centre for

Irrigation Technology, Florida is to transform the application rates to different intensities/ densities of dots. The wettest area is displayed as black (solid dots); all other application amounts are scaled between black and white (white represents area receiving no water or the dry spot) with corresponding shades or densities of dots. The resulting densogram gives an excellent visual description of where the high and low watering spots are, how wet or dry they are; and in general, how uniform the water application is.

The feel of over all uniformity of water application; for every emitter, can be produced by giving various shades to different application depths. The individual application depths can be transformed to values represented as percentage of average application depth. Since they are represented as percentage of the average application depth of the corresponding emitter, the emitters can be easily compared for their performance. The densogram will show how much a particular area over-irrigated or under-irrigated as compared to the targeted application rate (corresponds to average application depth, i.e. 100%).

Boman (1989) has evaluated several micro-sprinklers to determine their individual performance. He reported that the application rate of several micro-sprinklers was not very uniform. Some emitters put out a ‘doughnut’ pattern where more water is thrown to the outside and less remains near the centre (an increase and then decrease in application rate from centre to outside). Distribution patterns of a number of micro-sprinklers are shown, to clearly describe their performance. Only one of the emitters tested had a DC value greater than 50%. Apparently, low DC values (less than 50%) are typical for micro-irrigation sprinkler and spray emitters. The average COV values for the spray emitters tested were 181, 165 and 167, and for the spinner emitters were 101, 71 and 73 respectively for the 103, 138 and 172 kPa tests. The higher COV values in the 103 kPa tests were due to a more pronounced doughnut effect in some of the emitters at the lower pressure. This problem is common for high-pressure sprinklers that are operated at too low pressure.

Pandey et al.(1995 a) determined the performance parameters such as average application rate, absolute maximum depth and coefficient of variation by single nozzle test for five makes of micro-sprinklers, designated for reference as A, B, C, D and E. The range of mean depth at varying pressures and heights for micro-sprinklers A, B, C, D and E respectively were found to be 6 to 2 mm, 6 to 4 mm, 16 to 5 mm, 3 to 2 mm and 9 to 2 mm and the range of COV were found to be 254 to 76, 207 to 90, 189 to 66, 199 to 105 and 215 to 63 respectively.

2.5.3 Effect of pressure on distribution uniformity

The operating pressure is one of the main factors influencing the distribution uniformity of a micro-sprinkler system. The operation of a micro-sprinkler system at a very low or very high pressure (compared to the optimum/ recommended operation pressure) will result in poor uniformity.

Post et al. (1985) reported that most of the emitters tested had no appreciable difference in its DC when operated at the three testing pressures, but coefficient of variation has shown remarkable variations.

Boman (1989) reported that a slight drop in the operating pressure (from 138 kPa to 103 kPa) has caused a sudden increase in COV of all the emitters tested. The COV of some emitters more than double with this pressure drop. The development of a doughnut pattern was also observed, when the operating pressure was dropped. At 172 kPa most of the emitters have shown very good performance, at 138 kPa, beginnings of a doughnut pattern near the outer perimeter of the distribution pattern was observed. The emitters when operated at 103 kPa, has produced a pattern with a well-developed ‘doughnut’.

2.5.4. Management of the irrigation system

Improved irrigation system hardware or management may result in greater distribution uniformity and improve the potential for higher application efficiency. It follows that distribution uniformity is the first concern when improving irrigation system performance. Achieving high application efficiency ultimately depends on the management of the system. *(Hermanson and Canessa, 1995)*

Responding to the increased demand, new developments have made many more brands of micro-sprinklers and spray patterns available. A number of manufacturers have introduced new emitters to the market. Today, growers have an extensive choice of emitters that vary widely in output discharge, spray diameter and spray patterns. This large selection of emitters is beneficial but the growers may be unaware of the performance capacity of the emitters. Accurate information on the efficiency/ uniformity of various patterns produced by the emitters is very essential for better designs of irrigation systems and for good irrigation management. When selecting a nozzle, the grower should insist on seeing the information regarding the performance (irrigation efficiency or uniformity of application) and should look for a brand/ model that have a relatively flat emission with distance from the emitter.

MATERIALS AND METHODS

MATERIALS AND METHODS

Comparative evaluation of different micro irrigation systems were done under field conditions, using Banana as an indicator plant. During this experiment, biometric observations, various performance indices and moisture distribution pattern of micro sprinklers were considered.

3.1. Principle of micro irrigation systems

The ever increasing demand for water and the resulting water scarcity have focused the need for adopting water saving irrigation systems and techniques which wet only the root zone of the crops at the most desired periods. Micro irrigation is a method of applying low volumes of water directly to the root zone of the crop and limiting it to the root spread volume of the soil layer. Losses due to surface evaporation and deep percolation are avoided. By this method the water can be saved up to 50-70% and have an overall efficiency of 80-90%.

3.2. Location

The site for conducting the experiment was selected at one of the experimental plots of PFDC, located at KCAET farm. An area of 22 cents was selected for conducting the experiment.

A filter point well was used as the primary source of irrigation located near the experimental plot. An engine operated pump set of 3 hp was used to lift the water from the filter point well.

3.3. Layout of the system

The total area was divided into six rows by furrows. Each row consists of ten basins.

Each basin consists of three suckers, which were planted at the corners of 1× 1×1m triangle. Center to center distance of consecutive basins in the rows is 3 m and column wise distance is 4 m. Basin irrigation and micro irrigation were used for the experimental plot. Basin irrigation was given to the first two basins of each row. Under micro irrigation micro sprinkler, KAU model micro sprinkler, bubbler and dripper were used and each of which is used to irrigate 12 basins.

Table 2. Location of irrigation system.

6th row	5th row	4th row	3rd row	2nd row	1st row
$B_{6,1}$	$B_{5,1}$	$B_{4,1}$	$B_{3,1}$	$B_{2,1}$	$B_{1,1}$
$B_{6,2}$	$B_{5,2}$	$B_{4,2}$	$B_{3,2}$	$B_{2,2}$	$B_{1,2}$
$R_{6,3}$	$C_{5,3}$	$S_{4,3}$	$D_{3,3}$	$R_{2,3}$	$C_{1,3}$
$R_{6,4}$	$C_{5,4}$	$S_{4,4}$	$D_{3,4}$	$R_{2,4}$	$C_{1,4}$
$R_{6,5}$	$C_{5,5}$	$S_{4,5}$	$D_{3,5}$	$R_{2,5}$	$C_{1,5}$
$R_{6,6}$	$C_{5,6}$	$S_{4,6}$	$D_{3,6}$	$R_{2,6}$	$C_{1,6}$
$S_{6,7}$	$R_{5,7}$	$D_{4,7}$	$C_{3,7}$	$S_{2,7}$	$D_{1,7}$
$S_{6,8}$	$R_{5,8}$	$D_{4,8}$	$C_{3,8}$	$S_{2,8}$	$D_{1,8}$
$S_{6,9}$	$R_{5,9}$	$D_{4,9}$	$C_{3,9}$	$S_{2,9}$	$D_{1,9}$
$S_{6,10}$	$R_{5,10}$	$D_{4,10}$	$C_{3,10}$	$S_{2,10}$	$D_{1,10}$

B – Basin irrigation

C – KAU Micro sprinkler

S - Micro sprinkler

R – Bubbler

D- Dripper

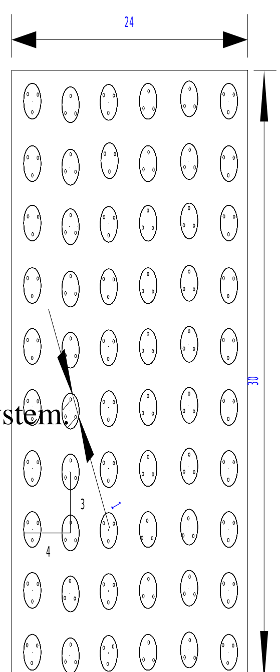


Figure 1. Layout of irrigation system.

3.4. Schedule of irrigation

The suckers of Nendran variety were planted at the month of November. There was reasonable rainfall till the end of December. From the first of January, regular schedule of irrigation as per treatment was started. In the micro irrigation method, plants were irrigated every day whereas, in the basin method, the plants were irrigated once in three days. Irrigation schedule continued up to the middle of May, after that monsoon rain was started.

3.5. Biometric observations

The following observations were taken:

1. Plant height
2. Girth
3. Number of leaves
4. Yield

3.5.1. Statistical analysis

The biometric observation such as yield, height, girth and number of leaves were taken for statistical analysis. There were five treatments of Basin, Drip, ALBL micro sprinkler, Bubbler and KAU micro sprinkler irrigations, each with three replications.

3.6. Evaluation of micro-irrigation emitters

The general test conditions and equipments are detailed in this section.

3.6.1. Location

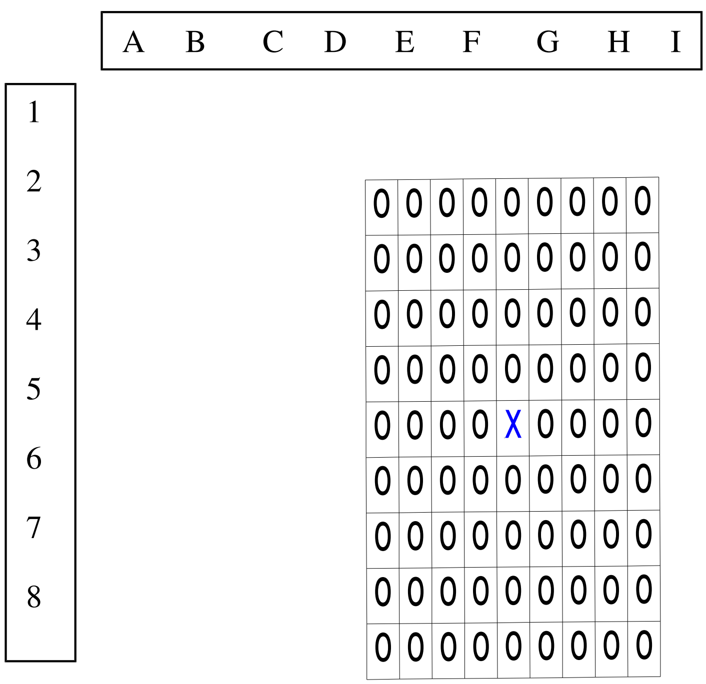
The present study was aimed at evaluating the performance of various micro-sprinkling devices; including the analysis of distribution pattern and uniformity of application of the irrigation devices. Since such experiments require a windless condition, the present study was conducted inside the SWCE (Soil and Water Conservation Engineering) laboratory, K.C.A.E.T., Tavanur. The place is in Malappuram district, situated at 10°52´30´´ North latitude and 76°East longitude.

3.6.2. Experimental setup

The area selected inside the laboratory for the present study was cleared and boundaries were marked. The floor surface was level so that the micro-sprinkler when mounted over the stake remained vertical. Water was filtered before collecting in the tank.

A centrifugal pump (0.5 HP, 50 m of total head) operated by an electric motor was used to create the necessary pressure to operate the emitters. The main line was constituted by 32 mm Ø PVC pipe and the lateral by 16 mm Ø LDPE tube. One gate valve connected to the delivery line of the pump was used to control the discharge from the pump and a pressure gauge was used to monitor the pressure head applied. A pressure gauge of 0 - 7 kg/cm² (± 1%) was connected to the mainline such that it indicated the pressure head near the base of the emitter. The Figures 8, 9, 10, 11 and 12 shows different views of the experimental setup.

Figure 7. Grid pattern of catch-can arrangement



3.6.3. Emitters

The number of micro-sprinkler models selected for the present study was three. The emitter samples were randomly selected, by choosing few numbers of each of the three different models. The emitters were KAU Micro sprinkler, Bubbler and ALBL micro sprinkler. Figures 13, 14 and 15 shows different micro sprinklers used for performance evaluation.

3.6.4. Functional test

The testing pressures selected for this were 1.0 kg/cm², 0.75 kg/cm² and 0.5 kg/cm².The pressure of 0.75 kg/cm² being the recommended operating pressure; 1.0 kg/cm² and 0.5 kg/cm² falling outside the effective operating pressure range.

As per the instructions of the manufacturer and recommendation of the test standards, the emitter was connected to the LDPE lateral (either directly by means of the adaptor or using a spaghetti micro tube). The emitter connected to the lateral was mounted on a stake assembly and was placed inside a collection vessel. The water pressure of the system was raised to the required testing pressure and a small plastic vessel was placed over the emitter without disturbing the operation, to confine and direct the stream ejected from the emitter to the collection vessel. Figure 19 shows the arrangement for discharge measurement.

The discharge from the emitter was collected for a specific known period of time and the flow rate of the emitter was calculated as,

$$\text{Flow rate (lph)} = \frac{\text{volume of water collected (ml)/ 1000}}{\text{Time (min)/ 60}}$$

The procedure was repeated for each pressure and each micro sprinkler model. The functional relationship (pressure Vs discharge) of each model was established by plotting the flow rate against the operating pressure.

3.6.5. Operational test

Indoor measurement of micro-sprinkler patterns were carried out to analyse the distribution performance of the emitter. The technique of catch-can test was considered to be suitable for this purpose

3.6.5.1. Test Equipment

Catch-cans were placed on 60 cm grid intervals in a matrix extending to a distance of 2.1m from the emitter, on either side. The emitter was placed exactly at the centre of the matrix. The collectors were 2 litre straight walled cans made of virgin plastic material. The catch-cans were placed at the centre of each square formed by the grid, assuming that each catch-can represents the precipitation rate over that area of 60 cm x 60 cm. The catch-cans were named according to their relative distance and position with respect to the emitter location. The nomenclature of the collectors is shown in Appendix 1. A stake assembly was used to hold the emitter at a height of 20cm above the horizontal plane of the openings of the catch-cans; care was being taken that the stake riser was fixed vertically and did not bend or deviate from that position during the tests. Plate 19, 20 and 21 shows the stake assembly of Bubbler, ALBL micro sprinkler and KAU micro sprinkler respectively.

The collector at the geometric centre of the matrix of catch-cans surrounded by the adjacent eight collectors was removed and the emitter mounted on the stake was placed there.

3.6.6. Performance testing

Before conducting the test, the emitter was operated at the test pressure for some time to wet the surroundings and to ensure trouble free operation. The emitter was then operated for a period of 1 hr while maintaining the test pressure. The emitters were tested at the recommended operating pressure and minimum and maximum effective operating pressures in three replications. Immediately on conclusion of the test the amount of water collected in each can within the spray coverage area was measured and recorded against the corresponding catch-can location.

3.6.7. Distribution performance

The catch-can data collected after each test was used to analyse the performance of each micro-sprinkler model. The different factors or indices used to analyse the performance are wetted radius, average application depth, uniformity coefficient, coefficient of variation, distribution characteristic and the distribution patterns.

3.6.8. Determination of wetted radius

The wetted radius was calculated to be the distance measured from the emitter location to the farthest point at which the emitter deposits water at a minimum rate of 0.26 mm/hr; typically measured at any arc of coverage.

3.6.9. Determination of application depths

The maximum application depth (Dx) was determined as the greatest depth caught in any of the containers for a particular emitter, in cm. The mean application depth (Da) was calculated by averaging the depths of water caught in the cans located within a distance of 2.1 m from the emitter.

3.6.10. Performance indices

The various performance indices used to describe the uniformity of application of the emitters were calculated and the distribution patterns were plotted to get an exact understanding of the water distribution by the emitters.

3.6.10.1. Coefficient of uniformity

The Christiansen's uniformity coefficient was calculated as

$CUC = 100(1 - da/Da)$; where 'CUC' is the Christiansen's uniformity coefficient (%)

'da' is the average absolute deviation from Da

Where $$da = \frac{\Sigma |di - Da|}{N}$$

'di' is the individual application depth

'|(di-Da)|' is the absolute deviation of di from Da

'N'is the total number of individual application depths.

3.6.10.2. Coefficient of variation

The coefficient of variation (COV) of the application depths for a particular emitter was calculated by dividing the standard deviation of the application depths by the mean application depth, expressed as a percentage.

COV = (SD/Da) x100; where 'SD', is the standard deviation of individual application depths

3.6.10.3. Distribution characteristic

'Merriam and Kellers' distribution characteristic (DC) was defined as the ratio of the area; which receives more than half of the average application depth to the total wetted area, expressed as a percentage. The coefficient was calculated as the ratio of the number of individual application depths greater than half of the mean application depth (i.e. > Da/2) to the total number of the individual application depths.

$$DC = \frac{\text{Area receiving more than half of the mean application depth}}{\text{Total wetted area}}$$

$$= \frac{\text{n, number of individual application depths, greater than Da/2}}{\text{N, total number of individual application depths}}$$

3.6.10.4. Ranking

The method of ranking of different performance parameters was used to compare the individual performance of the emitters at different applied pressures. The final ranking of the total value (sum) of each performance parameter (in three replications) was done to analyze the relative performance of the emitters, among themselves. The emitters were ranked from I to III according to their performance, based on CUC, COV and DC.

3.6.10.5. Distribution pattern

The catch-can data was used to plot the distribution pattern corresponding to the spray coverage of the emitters. For a particular test, the amount of water collected in each catch-can was expressed as a percentage of the mean application depth, Da. The computer software 'SURFER' was used to plot the curves by connecting the interpolated points of equal collection (application) rates. The software fills the area between the contour lines; the isograms, connecting points of equal collection rates according to the levels specified. Thus the contour lines and the filled area together formed the distribution pattern.

3.6.11. Comparison Analysis

The different performance indices were used to compare the performance of each micro-sprinkler.

3.6.12. Statistical method

The analysis of various performance parameters (CUC, COV and DC) of the emitters were done to evaluate their relative performance, separately for the test groups. The RBD (Randomized Block Design) technique was used to compare the yield and other biometric observations.

3.6.12. Economic analysis of different irrigation methods

Economic analysis is done and benefit-cost ratio is calculated for each irrigation methods with an assumption that the particular method is employed to the total area under study. The fixed and variable cost is considered for the calculation of the total cost. The life span of the pump and motor are assumed as 10 years and the other components including pipes, fittings and emitters are assumed as 5 years respectively. Junk value is taken as 10% of the cost and annual cost of the components are computed. Depreciation is calculated by the following equation.

$$\text{Depreciation} = \frac{\text{Initial cost} - \text{Junk value}}{\text{Life span}}$$

The present market cost of the components is considered for the analysis. The subsidized electricity cost which is used in the analysis is at a rate of Rs.0.92/- per kWh. The power of the pump used is 1Hp with 80% motor efficiency. The pump pressure is maintained at 1kg/cm^2 and with a discharge of 7.5 lps. The discharge of emitters is found out by the lab test is used. The water for agricultural purpose is assumed to be available at a rate of Rs.5/- per cubic meter. The yield obtained from the studied area can be taken for the income calculation for all the methods, if there is not any significant difference exists. The crop was marketed at a rate of Rs.18/- per kg and a net income from yield was calculated.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Being the third fruit crop in India, Banana has an important role in Indian economy. The moisture loving character of banana is the cause of reluctance of its cultivation in water scarce area. Therefore, micro-irrigation systems that save the wastage of water need to adopt for widening the area under cultivation of banana.

The different irrigation methods including traditional basin and micro-irrigation were evaluated on a comparative basis to find a better efficient treatment, which may not badly affect the crop yield. A plot of PFDC at the KCAET farm was selected for the experiment for one complete crop season. The micro irrigation systems such as KAU micro sprinkler, ALBL micro sprinkler, Bubbler and Dripper were employed along with Basin irrigation for individual plant basin.

The comparison of these irrigation methods were done based on biometric observations before the emergence of bunch, and after that yield is taken in to account. The performance comparison among the different type of micro sprinklers is done based on CUC, COV, DC and Distribution pattern.

4.1. Biometric observations

The biometric observations such as height, girth and number of leaves of each plant were taken at four stages at 164, 175, 203 and 296 DAP.

4.1.1. Yield

The harvesting of banana was started 10 months after planting. The weight, number of hands and fingers were observed. The weight and number of hands and fingers of the plants studied under various irrigation treatments were given in Appendix III.

4.1.2. Plant height

From each of the three plants in a basin, the observations with respect to plant height were taken from one representative plant. The height observed after 164 days, 175 days, 203 days and 296 days were recorded and shown in Appendix III.

4.1.3. Girth

Girth of one representative plant is measured and expressed in 'cm'. The observations were taken 164, 175, 203 and 296 DAP and are shown in Appendix III.

4.1.4. Number of leaves

Number of leaves was counted at different critical stages such as 164, 175, 203 and 296 days after planting. The observations are recorded and shown in Appendix III.

4.2. Statistical Analysis of Biometric Observation

The crop yield and other biometric parameters observed are analyzed statistically to check the significant difference between each of the irrigation practice applied. It is inferred that there is no significant difference exists in the yield of crop among different micro irrigation treatment and basin irrigation practice. A slight higher yield was obtained under the treatment of KAU micro sprinkler. In addition, other biometric observations such as height, girth and number of leaves did not exhibit much difference accordingly with the treatments. There is only negligible deviation in mean and critical difference. Therefore, there is no significance of applied irrigation practice in yield and other biometric observations.

The level of significance of 5% is adopted for yield and other biometric observations. The Critical Difference (CD) obtained in yield is 2.059. Therefore statistical analysis of average crop yield in basin irrigation does not show a variation above Critical Difference with the micro irrigation methods. In addition, there is not much significant variation among the micro irrigation methods. In the case of height, girth and no. of leaves it is observed that there is not much variation based on the CD value. Here T1, T2, T3, T4 and T5 were Basin, KAU micro sprinkler, Bubbler, ALBL micro sprinkler and Dripper and s1, s2, s3 and s4 were four different critical stages.

Table 3.a. Statistically analyzed data of yield

Treatment	Yield
T1	7.04
T2	8.51
T3	7.82
T4	7.43
T5	7.97
SE	0.257
CD	2.059126

Table 3. b Statistically analyzed data of girth

Treatment	s1g	s2g	s3g	s4g
T1	31.08	41.25	42.08	44.75
T2	38.17	39.25	42.58	46.33
T3	39.67	42.42	44.5	45.58
T4	39.17	41.58	43.67	45.58
T5	37.67	41.42	43.08	47.25
SE	1.459	1.173	1.03	1.263
CD	4.126338	3.317429	2.93303	3.573234

Table 3. c Statistically analyzed data of height

Treatment	s1h	s2h	s3h	s4h
T1	210.67	226.83	263.08	287.917
T2	191.75	219.42	272	298.167
T3	215	236.5	284.91	304.167
T4	205.5	230.25	283.33	300.417
T5	202.25	228.25	281.25	303.083
SE	13.072	10.523	6.749	5.984
CD	36.97314	29.76396	19.08829	16.92643

Table 3. d Statistically analyzed data of leaves

Treatment	s1l	s2l	s3l	s4l
T1	13.667	15	15.667	16.67
T2	13.33	14.67	15.33	17
T3	14.33	14.67	16.33	18
T4	13.33	15	15.67	17
T5	15	15	15.67	16.33
SE	0.415	0.428	0.365	0.489
CD	1.174166	1.21106	1.032796	1.382751

4.3. Performance Evaluation of Different Micro Sprinklers

The various performance indices used to describe the uniformity of application of the emitters were calculated and the distribution patterns were plotted to get an exact understanding of the water distribution characteristics.

4.3.1. Flow rate

The flow rate of emitters was tested at different operating pressures. The pressures were selected in such a way that emitters were operated at 0.5, 0.75 and 1 kg/cm². The results of the tests are given in Table. 4. Since Bubbler and KAU shows higher discharge it can supply required amount of water at less time. The operating time required for the Dripper is higher compared with micro sprinklers.

Table 4. Pressure Vs. Discharge

Type of irrigation method	Pressure (kg/cm²)	Discharge (lit/hr)
KAU micro sprinkler	1.0	63.90
	0.75	54.72
	0.50	47.80
ALBL micro sprinkler	1.0	38.4
	0.75	32.48
	0.50	27.78
Dripper	1.0	13.2
	0.75	12.3
	0.50	11.4
Bubbler	1.0	85.2
	0.75	79.2
	0.50	61.4

4.3.2. Mean application depth

The mean application depth of the different micro sprinklers at various pressures were calculated by dividing the sum of the depths of water collected in each catch-cans by total number of observations. It is observed that the mean application depth is decreases as the pressure increases. Since Banana has shallow root system, a medium mean application depth is preferred. Higher depth of application may result in the wastage of water and very low application depth may cause the water unavailable to the roots. The Table 5.

Shows the mean application depths of each micro sprinklers at various pressure.

Table 5. Mean application depth of different micro sprinklers at various pressures

Type	**Pressure (kg/cm^2)**	**Mean application depth (Da) (cm)**		
		R1	**R2**	**R3**
KAU micro-sprinkler	0.5	33.91	41.88	31.40
	0.75	26.25	27.18	23.27
	1.0	27.5	25.56	20.65
ALBL micro sprinkler	0.5	15.73	14.38	16.04
	0.75	13.40	12.44	14.43
	1.0	12.40	12.67	13.20
Bubbler	0.5	43.45	155.55	147.73
	0.75	82.66	92.07	66.00
	1.0	64.76	110.41	44.03

4.3.3. Radius of throw

The wetted radius is calculated as the distance measured from the emitter location to the farthest point at which the emitter deposits water at a minimum rate of 0.26 mm/hr; typically measured at any arc of coverage. It is observed that the radius of throw increases as the pressure increases. The radius of throw should be maintained within the basin radius to make avail the water near the root zone. In the particular case of banana cultivation practised, the basin radius was 1.8m. Therefore, the field operating pressure should not be too high or low. KAU micro sprinkler and ALBL micro sprinkler have better performance in this context. Bubbler have very low radius of throw, which results the lack of uniformity of water application to the plants in a basin. The Table 6. shows the radius of throw of each micro sprinkler at different pressure.

Table 6. Radius of throw of each micro irrigation devices at different pressures

Type of micro irrigation device	**pressure (kg/cm^2)**	**Radius of throw (cm)**		
		R1	**R2**	**R3**
	1.0	197.50	180	195

Type of micro irrigation device	pressure (kg/cm²)	Radius of throw (cm)		
KAU micro sprinkler	0.75	195	172.50	180
	0.5	120	120	127.50
ALBL micro sprinkler	1.0	195	210	180
	0.75	165	180	180
	0.50	135	142.50	150
Bubbler	1.0	115	90	90
	0.75	82.50	75	90
	0.50	52.50	60	60

4.3.4. Christiansen's Coefficient of Uniformity (CUC)

The coefficient is computed from the observations of the depths of water caught in open pans placed at regular intervals within a sprinkled area. The ranking method is used to compare the CUC of the different emitters at different applied pressures. It has seen that ALBL micro sprinkler having the highest rank and the Bubbler have the lowest rank. The values of CUC and corresponding ranking were shown in the Table 7.

Table 7. CUC and Ranking of different micro sprinklers

Type	**Pressure (kg/cm²)**	**Christiansen's Coefficient of Uniformity (CUC)(%)**			**Average**	**Ranking**
		R1	***R2***	***R3***		
KAU Micro-sprinkler	0.5	32.59	44.67	9.55	28.94	III
	0.75	21.9	46.23	22.72	30.28	II
	1	51.15	51.26	44.46	48.96	I
ALBL micro-sprinkler	0.5	41.13	45.26	43.34	43.24	I
	0.75	44.46	43.46	49.08	45.67	I
	1	44.09	50.39	42.42	45.63	II
Bubbler	0.5	19.07	46.94	24.2	30.07	II
	0.75	23.77	10.19	29.42	21.13	III
	1	8.08	18.54	45.13	23.92	III

4.3.5. Coefficient of Variation (COV)

Table 8. Shows the coefficient of variation of catch-can depth data of the tests conducted. Since the coefficient of variation is the measure of the deviation of individual observation from the mean, higher values of COV represents poor distribution (large deviation from

the average application depth) and lower values represents better performance. The emitter having a COV value less than 100% indicates it possesses “good” performance.

Based on the COV values, the ALBL micro sprinkler is having the best performance. For the KAU micro sprinkler the COV values were very near to 100%, but in the case of Bubbler it is just above 100%.

Table 8. COV of different micro sprinklers

Type	**Pressure (kg/cm²)**	**Coefficient of variation (COV) %**			**Type**	**Ranking**
		R1	**R2**	**R3**		
KAU Micro-sprinkler	0.5	88.35	67.32	113.85	89.84	II
	0.75	92.30	73.87	122.56	96.24	II
	1	66.36	75.66	69.73	70.58	II
ALBL micro-sprinkler	0.5	78.13	65.46	76.56	73.38	I
	0.75	61.64	64.79	63.54	63.32	I
	1	69.59	63.61	67.57	67.64	I
Bubler	0.5	122.11	67.79	95.32	95.07	III
	0.75	97.96	112.72	90.90	100.53	III
	1	112.85	91.08	152.35	110.99	III

4.3.6. Distribution Characteristic

The Distribution Characteristics is calculated as the ratio of the number of individual application depths greater than half of the mean application depth (i.e. > Da/2) to the total number of the individual application depths. The Distribution Characteristics of each emitter is shown in Table 9. It has been suggested that the DC value greater than 50% are probably satisfactory and very good patterns result with DC values greater than 66%. The DC values of ALBL micro sprinkler are above 66% and therefore it exhibits best distribution pattern. For Bubbler and KAU micro sprinkler some of the DC values are below 66%. However, both of them are satisfactory.

Table 9. Distribution Characteristics of emitters

Type	**Pressure (kg/cm²)**	**Distribution Characteristic (DC) (%)**			**Average**	**Ranking**
		R1	**R2**	**R3**		

KAU Micro-sprinkler	0.5	51.5	57.57	40	49.69	III
	0.75	56.25	82.35	55.56	64.72	II
	1	83.33	69.56	65.38	72.76	I
ALBL Micro-sprinkler	0.5	69.57	66.67	66.67	67.64	I
	0.75	70	62.5	70	67.5	I
	1	66.67	74.07	60.61	67.12	II
Bubler	0.5	60	70	63.64	64.55	II
	0.75	55.55	53.57	64.52	57.89	III
	1	50	62.07	36.67	49.58	III

4.3.7. Distribution Pattern

The catch-can data is used to plot the distribution pattern corresponding to the spray coverage of the emitters. For a particular test, the amount of water collected in each catch-can is expressed as a percentage of the mean application depth, Da. It is found that ALBL micro sprinkler and KAU micro sprinkler are maintaining uniform patterns of depth at all the tested pressures while that is becoming disturbed in the bubbler as the pressure increases.

Figure 20.a. Distri g/cr

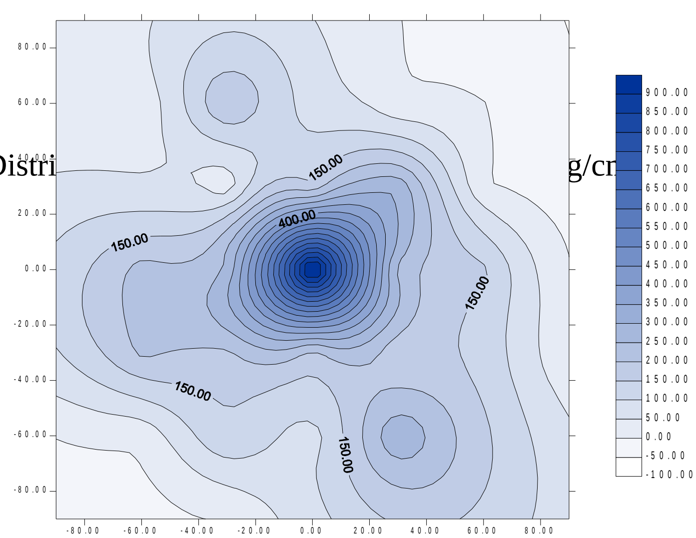


Figure 20.b. Distribution pattern of Bubbler at pressure 0.75 kg/cm²

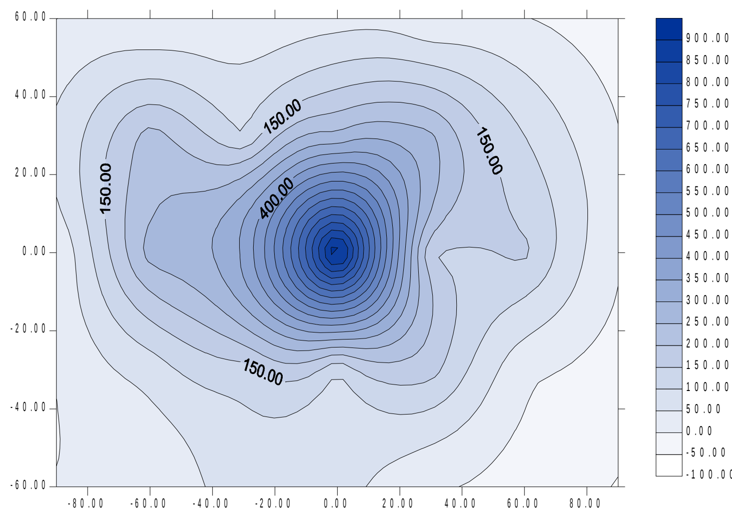


Figure 20.c. Distribution pattern of Bubbler at pressure 0.5 kg/cm²

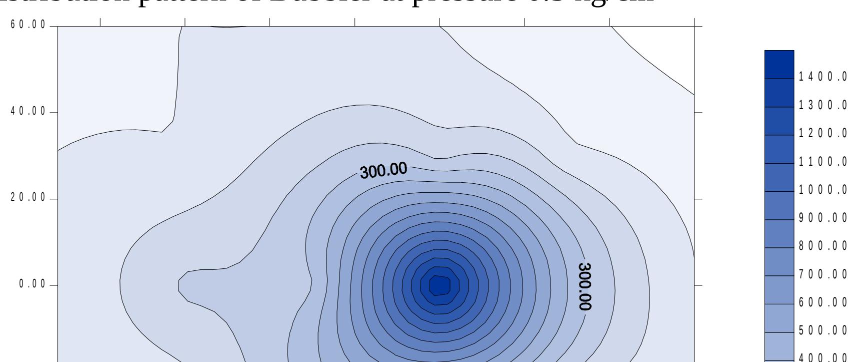


Fig 1 kg/cm²

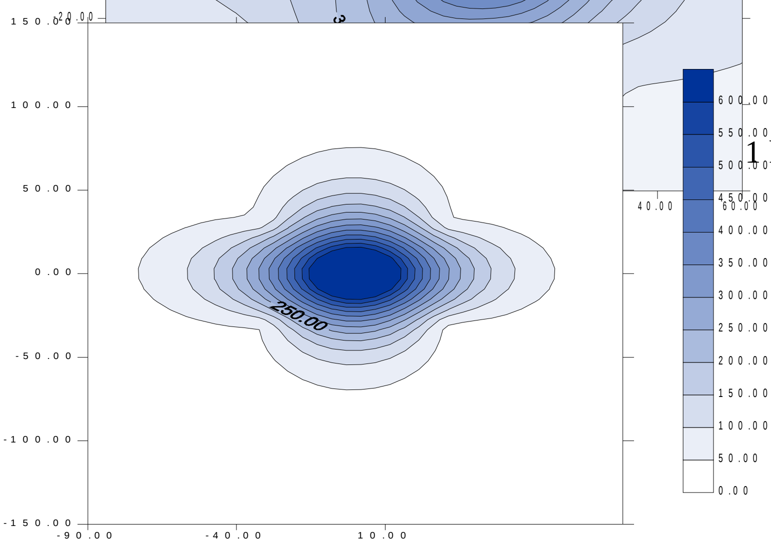


Figure 21.b. Distribution pattern of KAU micro sprinkler at pressure 0.75 kg/cm²

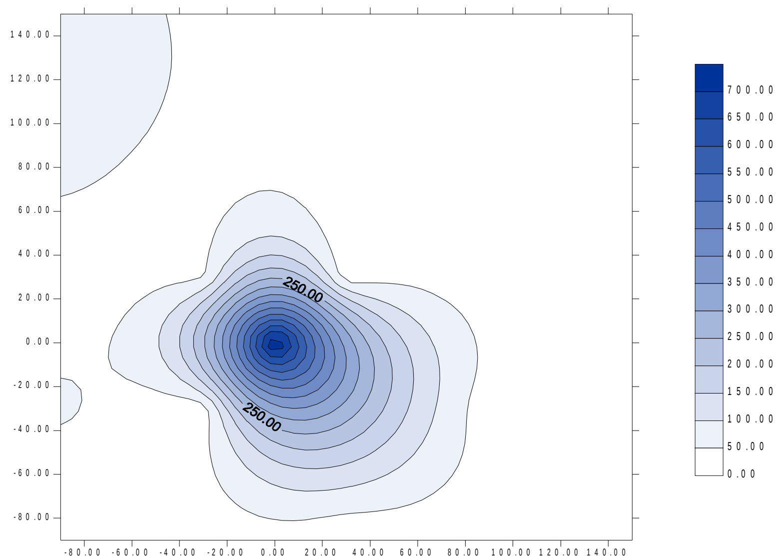


Figure 21.c. Distribution pattern of KAU micro sprinkler at pressure 0.5 kg/cm²

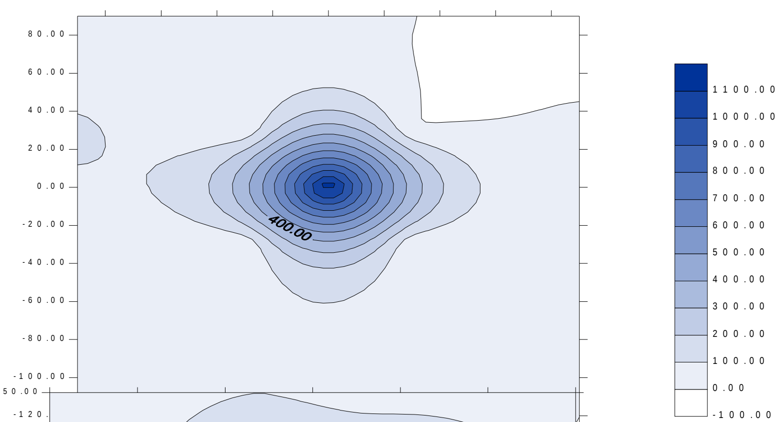


Figure 22.a. Distr ... at press e 1 kg/cm²

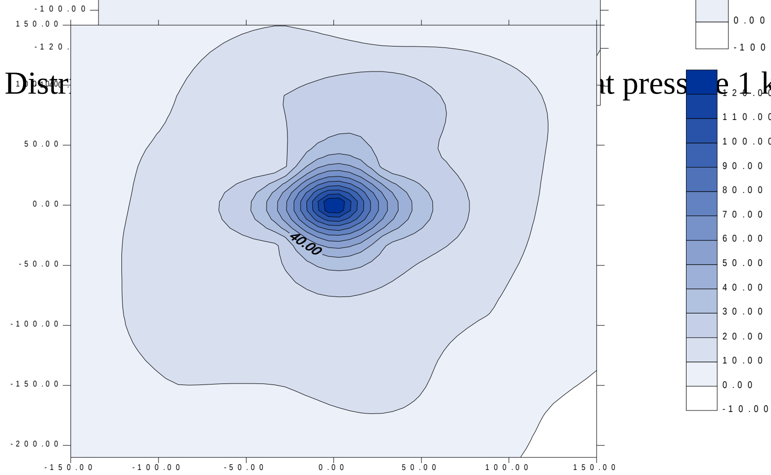


Figure22.b. Distribution pattern of ALBL micro sprinkler at pressure 0.75 kg/cm²

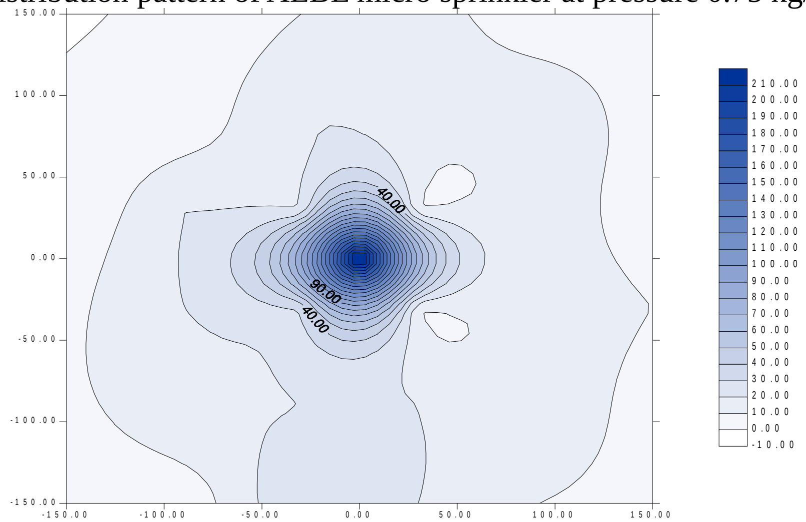
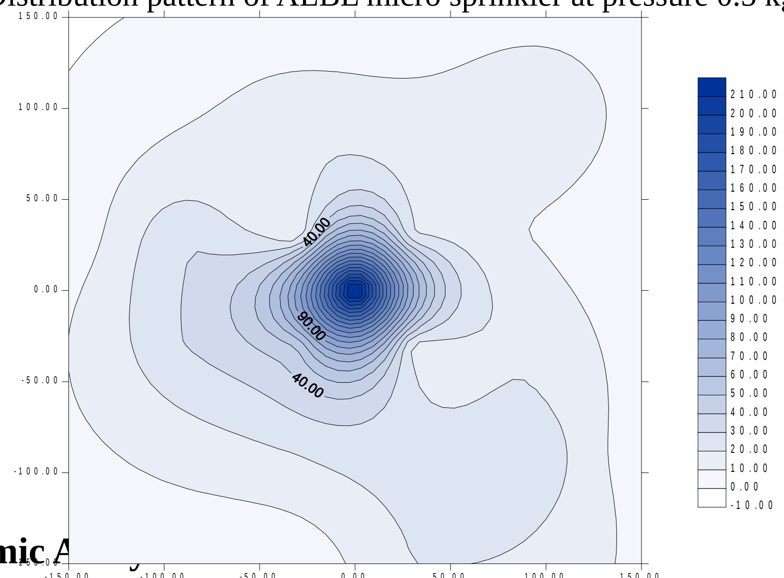


Figure 22.c. Distribution pattern of ALBL micro sprinkler at pressure 0.5 kg/cm²



4.4. Economic A

The economic analysis is done and it reveals that benefit-cost ratio is higher for all the micro irrigation methods. The return from the methods such as KAU micro sprinkler, Bubbler and dripper are almost same. The ALBL micro sprinkler shows slightly less B/C ratio. In the basin irrigation method B/C ratio is very less. The total yield obtained is 11.94 t/ha and the area of the studied plot is 0.088 ha.

Table 10.Economic analysis

	Basin irrigation	**KAU micro sprinkler**	**ALBL micro sprinkler**	**Bubbler**	**Dripper**
Fixed cost					
Pump with motor	337.50	337.50	337.50	337.50	337.50
Pipe fitting	258	990.49	1062.37	1033.69	1067.29
Initial installation	120	180	180	180	180
Planting	600	600	600	600	600
Total	1315.5	2107.99	2179.87	2151.19	2184.79
Variable cost					
Irrigation	12825	5840	5690.80	5827.68	5868.42
Electricity	87.4	260.10	422.64	195.08	195.08
Fertilizer and pesticide	500	500	500	500	500
Repair and maintenance	26.31	42.16	43.59	43.02	43.69
Interest on investment	105.24	164.64	174.38	172.09	174.78
Total cost	13543.95	6806.9	6831.41	6737.87	6781.97
Grand total	14859.45	8914.89	9011.28	8889.06	8966.76
Net Income	18909	18909	18909	18909	18909
Net profit	5365.05	9994.11	9897.72	10019.94	9942.24
B/C ratio	1.27	2.12	2.1	2.13	2.11

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

Banana is a succulent plant, requires high amount of water which shall be met either by well distributed rainfall or through irrigation. Because of its shallow root system, excess water applied invariably is faced due to percolation losses. Since water is a renewable resource, stress in the availability of water to meet the growing demand of the rising population has been increasing. Therefore, efforts have been on for employing more efficient methods of irrigation like micro irrigation.

The present study of comparing different micro irrigation systems on the crop geometry of banana was used to analyze the influence of irrigation biometrically and to identify the better micro sprinkler. The study was conducted by applying five treatments such as Basin irrigation, KAU micro sprinkler, ALBL micro sprinkler, Bubbler and Dripper. An experimental plot of PFDC was selected and the total area was divided into six rows and of ten basins, each with three suckers.

The biometric observation such as yield, height, girth and number of leaves were taken at four critical stages of growth. The statistical analysis of observations shows that there is no significant difference among different irrigation methods when biometric parameters are being concerned. Thus based on the available data it can be inferred that the excess application of water will not contribute much to the yield. KAU micro sprinkler has shown a slightly higher yield compared to the other methods. Bubbler also has better performance in crop production

The statistical performance indices of the emitters such as CUC, COV and DC have influence in crop growth. The ALBL and KAU micro sprinklers exhibits better distribution pattern at medium pressures and it ensures the irrigation water available to the root zone of each of the three plants in the single basin. Therefore the excess application and wastage of water can be avoid at a greater extend by adopting the micro irrigation methods for banana cultivation.

The mean application depth of different micro sprinklers at various pressures were studied and found that it tends to decrease as the pressure increases. On the other hand, the radius of throw increases as the pressure increases. The micro sprinklers were ranked based on their CUC and COV values. It has shown that ALBL micro sprinkler having the highest rank and the Bubbler shows the lowest rank based on CUC. Accordingly with the COV values also, ALBL micro sprinkler is ranked first.

The ALBL micro sprinkler has shown good Distribution characteristic followed by Bubbler and KAU. Although ALBL micro sprinkler have better statistical performance, it cannot be strongly recommended in the field because more pumping time is needed to reach the required depth of water to the crop root zone.

Economic analysis has been done for all the irrigation methods studied. The B/C ratio of different micro irrigation methods did not show much variation among themselves, while that of the basin irrigation system was too low. From the above observations it can be recommended that the micro irrigation methods can be effectively used for the cultivation of banana and in terms of financial benefits. Among the micro irrigation systems, KAU micro sprinkler and bubbler are found to have much better performance with respect to yield and economy.

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COMPARATIVE EVALUATION OF DIFFERENT MICRO IRRIGATION METHODS IN CROP GEOMETRY OF BANANA

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BHAVYA, P.R.
SREEKANTH, K.S.

ABSTRACT OF THE PROJECT REPORT

Submitted in partial fulfillment of the
requirement for the degree

BACHELOR OF TECHNOLOGY
IN
AGRICULTURAL ENGINEERING

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Land and Water Resources and Conservation Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR-679573, MALAPPURAM
KERALA
2008

ABSTRACT

The major problem associated with the banana cultivation is the excess amount of irrigation water required in the conventional farming method. Efficient application of water to the fruit crops is a very important consideration to improve the economy. The present study of comparing different micro irrigation systems on the crop geometry of banana is used to analyze the influence of irrigation biometrically and to identify the best micro irrigation method. The study was conducted by applying five treatments such as Basin irrigation, KAU micro sprinkler, ALBL micro sprinkler, Bubbler and Dripper. An experimental plot of PFDC was selected and the total area was divided into six rows and of ten basins, each with three suckers. The biometric observation such as yield, height, girth and number of leaves were taken for the comparative evaluation. The statistical analysis of the observed data shows that there is no significant difference among different irrigation methods in yield as well as crop growth. The testing pressures selected for the performance evaluation were 1.0 kg/cm^2, 0.75 kg/cm^2 and 0.5 kg/cm^2. The functional performance of the emitters was determined by analyzing the pressure - flow rate relationship. The various performance indices such as CUC, COV, DC and Distribution pattern were used to describe the uniformity of application of the emitters .It is observed that COV and CUC values were higher for ALBL micro sprinkler. The Distribution Characteristic of the emitters reveals that the ALBL micro sprinkler shows good characteristic and that of Bubbler and KAU are satisfactory. Economic analysis has been done for all the irrigation methods studied. The B/C ratio among different micro irrigation methods did not show much variation while that of the basin irrigation system was very low. The Benefit-Cost ratio obtained from Basin, KAU micro sprinkler, ALBL micro sprinkler, Bubbler and Dripper are 1.27, 2.12, 2.1, 2.13 and 2.11 respectively.