IMPACT: International Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS)
ISSN (P): 2347–4580; ISSN (E): 2321–8851
Vol. 05, Issue 04, Apr 2017, 1–12

IMPACT OF DRIP IRRIGATION SYSTEM CONFIGURATIONS ON BANANA

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Received: 03 Mar 2017 **Accepted: 15 Apr 2017** **Published: 20 Apr 2017**

ABSTRACT

A field experiment was undertaken to analyze effect of system configurations on banana productivity. Strip plot design with twelve treatment combinations comprised of irrigation regimes as a first factor with three levels viz 0.8 IW/ETc (I_1), 1.0 IW/ETc (I_2) and 1.2 IW/ETc (I_3) and system configurations as second factor with four levels viz; circular pattern (D_1), Single lateral (2X4 lph emitter) (D_2), Star emitter (D_3) and Single lateral (1X8 lph emitter)(D_4). Each treatment was replicated five times. The combined effect was analyzed in terms of initiation of flowering, plant girth, number of leaves, harvesting time, bunch weight, yield per hectare, numbers of finger and water use efficiency. Economics of each configuration and irrigation regimes was also calculated. System configurations significantly affected in banana crop. Irrigating around the plant yielded higher than a single point or two point application of water.

KEYWORDS: *Micro Irrigation, Drip Irrigation, Micro Irrigation in Banana*

INTRODUCTION

India has been a predominantly an agrarian economy since time immemorial. The developmental efforts over the last few decades have been doubtlessly strengthened our industrial base. However, agriculture continues to be the mainstay of our economy even today, as it contributes 21 per cent of national income and 67 per cent of the population still depends on it. Imbalances between availability and demand, the degradation of groundwater and surface water quality, inter-sectoral competition, interregional and international conflicts, all bring water issues to the fore. India suffers from acute water scarcity. Irrigated agriculture, which represents the bulk of the demand for water is the first sector affected by water shortage and increased scarcity, resulting in a decreased capacity to maintain per capita food production while meeting water needs for domestic, industrial and environmental purposes.

The production of fruits and vegetables is of vital importance as it provides three to four times more cash income than cereals per unit of land. Fruits and vegetables are the prime sources of vitamins and minerals without which human body cannot maintain proper health. Realizing the importance of horticultural crops, many farmers are directing their resources towards fruit crops. Major fruit crops grown in India are mango, banana, citrus, Gauva, pineapple, grape, pomegranate and Ber.

Banana plant is a tropical herbaceous evergreen that has no natural dormant phase. Banana fruit is consumed in fresh as well as in processed forms like Jam, Cordial, Chutney etc. It has a very good potential for export. It can be grown in all agro ecological conditions. Banana being a mesotype requires large amount of water because of large foliage area and moisture content of Pseudo stem. The total water requirement varied from 1841 mm to 2150 mm for various conditions. The total number of irrigations ranged from 22 to 78. Maintenance of high soil moisture (60 to 80% of available soil moisture) may be considered optimum for Banana. The traditional methods offer very low irrigation efficiencies. This is partly removed by high-frequency irrigation technique-like trickle irrigation.

Drip irrigation is superior to basin irrigation for banana in terms of technical and economic feasibility (Mohanakanthan 1983). Increased irrigation efficiency, reduced water stress, ease of automation, the ability to apply fertilizers and other chemicals with irrigation water, and low economic cost are some of the factors that have contributed to the increased popularity of trickle irrigation over the last few decades.

The main problem of adopting in this area to banana crop even after so many advantages is the amount of salts contained in the irrigation water. The drippers are frequently clogged due to large amount salts present in the irrigation water. The micro tube emitter is a simple and cheap emitter that was widely used throughout the world in drip irrigation. The length of micro tube can be adjusted according to the pressure distribution and the discharge required along the lateral line by its length. It is very cheap and drastically reduced the clogging problem. Successful design and management of drip systems, wetting pattern, emitter discharge, and irrigation schedule are the crucial factors for attaining optimum productivity, high irrigation and water use efficiency. Manufacturers adopt mainly two designs for banana crop (e.g Ring pattern and parallel lateral system). The ring design fails to deliver good efficiency due to clogging. The other design prevents the problem of clogging to a little extent but increase the cost of the system. Hence in the present effort a study is undertaken to give a good design which prevent the problem of water clogging and simultaneously reduce the cost.

MATERIALS AND METHODS

Gujarat is forefront in agriculture sector. After mango, bananas are one of the important horticulture fruit crops in the state. The climate in coastal Junagadh is moist and warm with annual rainfall between 700-800 mm received in 20-40 rain-days. The climate of the area is subtropical and semi-arid with an average pan evaporation of 6.41 mm/day. Temperature varies from 22°C to 44°C in summer and 10°C to 35°C in winter. The soil of the experimental plot was Clay in texture. The soil had organic carbon content of 1.17%, and was medium in available nitrogen and phosphorous and very much rich in available potash. It had field capacity of 0.45 cc of water per cc of soil. It had bulk density of 1.22 g/cc.

Soil Properties of Experimental Farm

The experimental field has an even topography with a gentle slope and good drainage. The physiochemical properties of the soil of experimental field are shown in Table 3.1. From Table we can see that the soil of the experimental plot was Clay in texture. The soil had organic carbon content of 1.17%, and was medium in available nitrogen and phosphorous and very much rich in available potash. It had field capacity of 0.45 cc of water per cc of soil. It had bulk density of 1.22 g/cc.

Table: 1 Physiochemical Properties Of The Soil Of Experimental Field

Sr. No.	Particular	Values
A.	**Physical properties**	
1.	Sand (%)	20.43
2.	Silt (%)	25.46
3.	Clay (%)	54.11
4.	Textural class	Clay
5.	Field Capacity (cc of water/ cc of soil)	0.45
6.	Bulk density (g/cc)	1.22
7.	Permanent wilting point(cc of water/ cc of soil)	0.31
8.	Plant available water (cc of water/ cc of soil)	0.14
9.	Saturated moisture content	0.5409
B.	**Chemical properties**	
1.	Organic carbon (%)	1.17
2.	pH (1:2.5)	8.40
3.	EC(1:2.5) (ds/m)	0.49
4.	Nitrogen (kg/ha)	240
5.	Phosphorous (P_2O_5) (kg/ha)	51.20
6.	Potash (K_2O) (kg/ha)	539.0

Chemical Properties of Irrigation Water

The source of water for the experiment was ground water. The diameter and depth of the dug well were 3 m and 50 m respectively. The analyzed quality of the irrigation water was as depicted in Table 3.1. The water table depth varied from 3 to 5 m. The quality analysis revealed that the quality of water was good for irrigation. The ground water of the region of Veraval Taluka contain high amount of salt but the experimental site is well far away from the sea so it was not much affected from salts. Seeing the water quality analysis of the irrigation water of the experiment site, it looks better for the cultivation of the orchard crop like banana. Water quality is also found good for the drip irrigation use.

Table: 2 Quality Analysis of Irrigation Water

S. N	Constituents	Values
1	Carbonate (meq/l)	1.56
2	Bicarbonate (meq/l)	9.39
3	Calcium (meq/l)	3.03
4	Chlorine (meq/l)	6.14
5	Sodium (meq/l)	7.8
6	EC (ds/m)	1.53
7	PH	8.29
8	Magnesium	4.03
9	Sodium absorption ratio (SAR)	3.54
10	Salts (g/litre)	1.126

FIELD EXPERIMENTAL DETAIL

The experiment was under taken to study four geometries of drip system configuration. The four geometries considered are circular patterns (D1), single lateral with two numbers of 4lph emitters (D2), star emitter (D3) and single lateral with single emitter of 8 lph (D4).

Circular Pattern (D1): Circular (loop system) geometry of lateral is well known technique in many of horticultural crop. In banana plantation most roots are usually found within 0.6 m of the base of the plant (M. K. V. Carr, 2009). Therefore, in case of banana plant it is desirable to apply water surround the plant for well water extraction by roots of plant. In this geometry a single lateral line of 16 mm was connected to the sub main with a lateral cock at the starting of lateral to control water supply. The radius of the ring was kept 30 cm from the base of the plant for uniform distribution of water. After that four numbers of online drippers of 2 lph were fitted on this circular ring (Plate 1).

Figure 1: Plate 1. Circular Geometry of Lateral with Four 2lph Dripper.

Figure 2: Plate 2. Single Lateral with two Number of 4 Lph Dripper.

Single Lateral Pattern with two Dripper (D2)

Application of water surround the plant might be a good design but it also increases the cost of the system because of increase in the length of the lateral. So in other treatment it was decided to use only a single lateral with two numbers of online emitter. Two numbers of online emitter of 4 lph was fitted per plant, 30 cm apart from base of plant (Plate 2).

Star Microtube Emitter (D3)

This star emitting device was primarily developed by Bhatnagar and Shrivastava (2003) for gravity fed irrigation system for vegetables. Star emitter delivers water at four different points around the plant. A single micro tube does have higher discharge and can deliver water at a single point only that is why in present investigation star layout of microtube has been adopted which can deliver water at four different points around the plant (Plate 3 and Plate 4).

The star emitter mainly consisted of 12 cm of LLDPE pipe folded by 1.5 cm at both ends with end caps. The star emittr is connected to the lateral with a microtube of 16 cm of 1.2mm diameter. In microtube discharge (Q) decreased with increase in length of microtube for fixed head and diameter, and increased: (a) with increase in diameter for fixed head and length and (b) with increase in head for fixed length and diameter (Vekaria et. al., 2010)

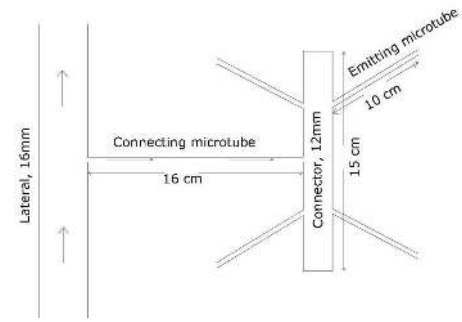


Figure 3: Plate 3. Line Diagram of Star Emitter.

Figure 4: Plate 4. Star Emitter Configuration.

Single Lateral Pattern with one dripper (1×8 lph) (D4)

In this design one single lateral of 16mm was connected to the sub main line. A lateral cock of 16mm was placed at the beginning of lateral. A single emitter of 8 lph was placed near to plant (Plate 5).

Figure 5: Plate. 5 Single Lateral with one Dripper of 8 Lph.

Statistical Design of Experiment

In the present investigation impact of three irrigation regimes and four drip system geometries were analyzed. Therefore total 12 numbers of treatments are to be statistical analyzed. Strip plot field lay out was used to find the impact of different treatments. Treatments were replicated five times. The first factor was irrigation regimes and the second was drip system geometry. The information regarding the treatments and replications are presented in the following Table 3.3 and 3.4. The layout of the experiment is depicted in plate 3.6.

Table: 3 Details of Factors

Factor 1. Irrigation Regimes	
I1	0.8 IW/ETc
I2	1.0 IW/ETc
I3	1.2 IW/ ETc
Factor 2. Drip system geometries	
D1	Circular geometry
D2	Single lateral with 2 X 4lph emitter
D3	Star emitter
D4	Single lateral with 1 X 8 lph emitter

Table: 4 Details of Treatment

Treatment	Irrigation Ratio	Drip system configuration
T00	0.8 IW/ETc	Circular pattern (4 x 2 lph)
T01	0.8 IW/ETc	Single lateral (2 x 4 lph)
T02	0.8 IW/ETc	Star microtube emitter (1 x 20 lph)
T03	0.8 IW/ETc	Single lateral (1 x 8 lph)
T10	1.0 IW/ETc	Circular pattern (4 x 2 lph)
T11	1.0 IW/ETc	Single lateral (2 x 4 lph)
T12	1.0 IW/ETc	Star microtube emitter (1 x 20 lph)
T13	1.0 IW/ETc	Single lateral (1 x 8 lph)
T20	1.2 IW/ETc	Circular pattern (4 x 2 lph)
T21	1.2 IW/ETc	Single lateral (2 x 4 lph)
T22	1.2 IW/ETc	Star microtube emitter (1 x 20 lph)
T23	1.2 IW/ETc	Single lateral (1 x 8 lph)

IRRIGATION REQUIREMENT

Water requirement of crop is the quantity of water regardless of source, needed for normal crop growth and yield in a period of time at a place and may be supplied by precipitation or by irrigation or by both. Water is needed mainly to meet the demands of evaporation (E), transpiration (T) and metabolic needs of the plants, all together is known as consumptive use (CU).

$$IR = \frac{ETcrop \quad ER}{\eta_a} \qquad (3.1)$$

Where, IR is irrigation requirement of plant, ETcrop is evapotranspiration by plant and ER is effective rainfall and η_α is application efficiency.

RESULTS AND DISCUSSIONS

PRESSURE DISCHARGE RELATIONSHIP OF STAR EMITTER

The Flow rate verses discharge head relationship plays a vital role in the characterization of emitters. It is one of the key factors in selecting an emitter and system design. In this study a relationship between flow rate and pressure head was developed using polynomial regression. It was observed from the graph that the discharge was linearly varying with pressure. The pressure range was taken from 0.4 to 1.4 kg/cm^2. The linear relationship holds good up to considered pressures. If the pressure discharge relationship considered beyond the present range then definitely an exponential relationship will be observed due to limitation of capacity of the emitter irrespective of pressure increase.

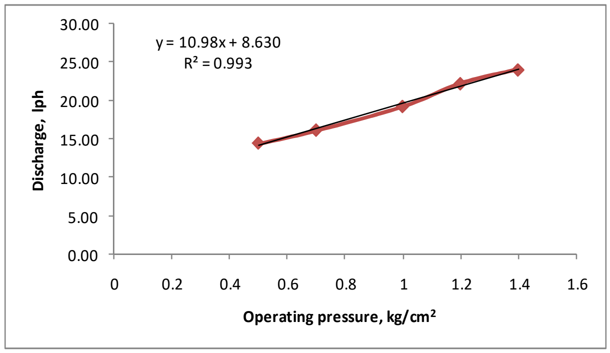


Figure: 6 Pressure V/S Discharge Diagram of Star Emitter

Climatic data such as temperature, humidity, rainfall, and daily evaporation were used to calculate the daily irrigation requirement of the crop. The mean temperature varied from 18°C to 34°C during the whole year.

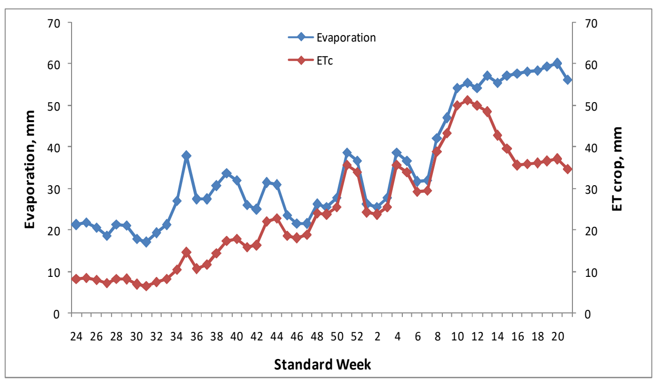


Figure: 7 Evaporation and Calculated Etcrop of the Experimental Field During Year of Experiment

Impact of System Configuration on Initiation of Flowering

Floral initiation in banana occurs after 30–35 leaves have been produced. This occurs at the apex of the rhizome, which is located within 0.3 m of the soil surface, following which the aerial stem begins to elongate pushing through the centre of the pseudostem until it is visible at the top (a process known as shooting). The results revealed that earlier flowering was observed in treatment D_3 (196.27 days after planting) followed by D_1, D_2 and D_4. Treatment D_3 was at par with D_1 and better than D_2 and D_4. Treatment D_2 was found better than D_4. Late flowering initiation was observed was in treatment D_4 (217.27 days after planting) may be due to in single emitter lateral spread of water is lower and wetting area is smaller as compare to the other treatments.

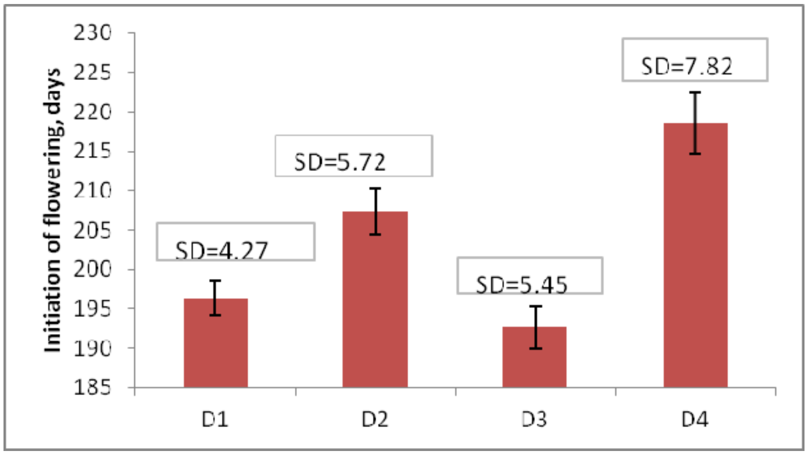


Figure: 8 Impact of System Configurations on Initiation of Flowering

Impact of System Configurations on Plant Girth

A banana tree is not really a tree because it has no woody trunk. The trunk is formed from the bases of overlapping leaves. The system configuration significantly influenced the girth of plant at harvest time. Higher girth was found with treatment D3 (74.29 cm) followed by D2, D1 and D4. Treatment D1 and D3 were statistically at par with each other and similarly D2 and D4 were also at par with each other.

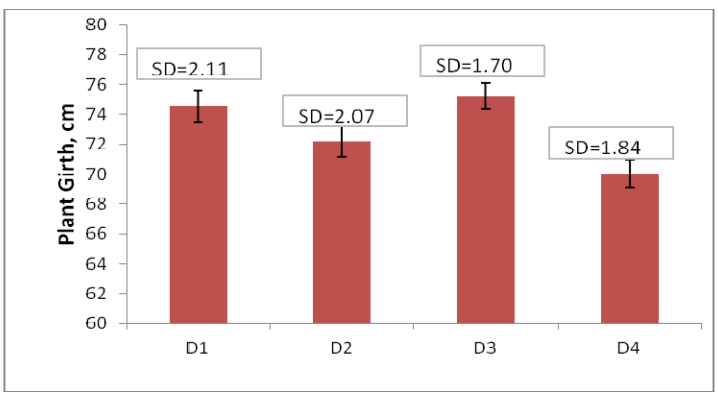


Figure: 9 Impact of System Configurations on Plant Girth

Impact of System Configurations on Harvesting Time

The system configuration significantly influenced the harvesting time. Treatment D_3 recorded earlier harvesting (346.20 days) followed by I_1, I_2 and I_4. There was no any difference in harvesting time between treatment D_1 and D_3 but both of these gave better results than D_2 and D_4.

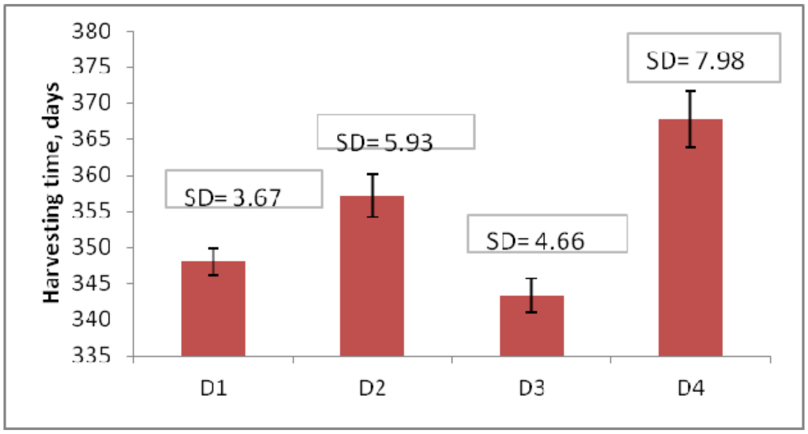
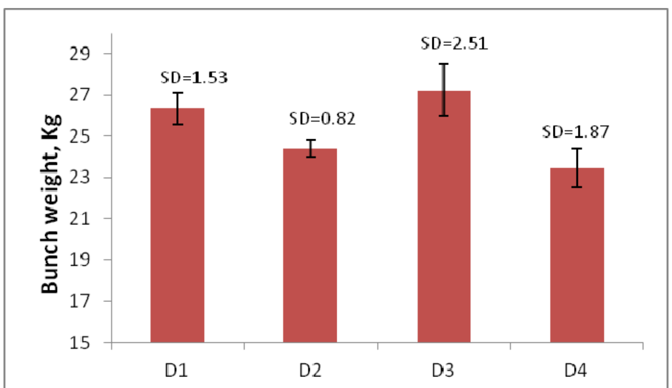


Figure: 10 Impact of System Configuration on Harvesting Time

Impact of System Configurations on Bunch Weight

In system design with Treatments D_3 recorded highest bunch weight followed by D_1, D_2 and D_4. Treatment D_3 and D_1 were statistically not different and they were found at par with each other but both of these treatments gave higher yield than treatment D_2 and D_4. Treatment D_2 and D_4 were found at par with each other. This yield difference may be because of low water availability to plant roots and low wetting area around the plant.



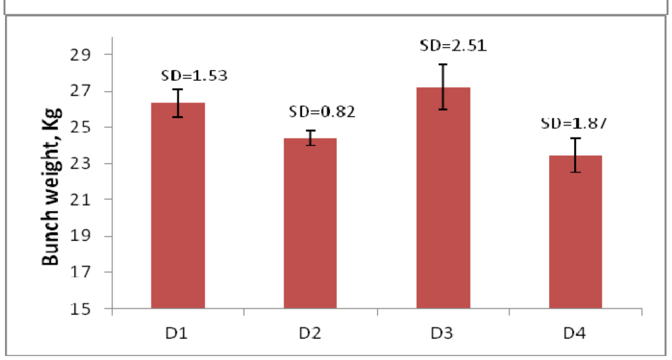


Figure: 11 Impact of System Configuration and I_2 on Bunch Weight

Impact of system configuration on yield per hectare

The system configuration significantly influenced the yield per hectare. Treatment D_3 recorded highest yield (86049.55 kg) followed by D_1, D_2 and D_4. Treatments D_3 and D_1 were found at par with each other but better than D_2 and D_4. Treatments D_2 and D_4 were also gave similar results. Treatment D_3 and D_1 gave better yield than treatment D_2 and D_4. Graphical representation is shown in figure 4.45 to 4.47.

The results revealed that there was no significant difference in yield per hectare due to interaction Impact of irrigation regimes and system configuration. However, highest bunch weight was observed in treatment I_3D_3 (91648.49 kg) and lowest was in I_1D_4 (65319.02 kg).

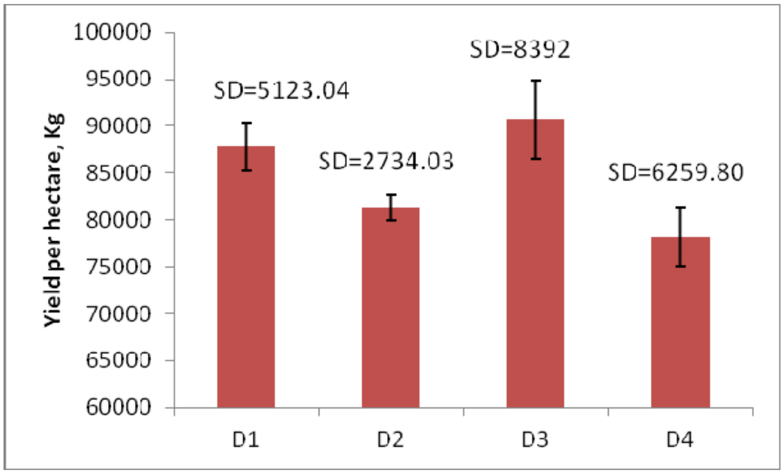


Figure: 12 Impact of System Configurations and I_2 on Yield Per Hectare

Water use Efficiency of Crop

The data on water use efficiency are given in Table 4.17 which shows that treatment I_1D_3 and I_1D_1 gave higher water use efficiency of 80.30 kg/ha-mm and 72.12 kg/ha-mm respectively than rest of the treatment, lowest water use efficiency of 55.18 kg/ha-mm was found under treatment I_3D_4. Water use efficiency was in accordance with yield for respective treatments.

Table: 5 Effect of Irrigation Method on Water use Efficiency

Treatment	Yield kg/ ha	Depth of Irrigation, mm	Water Use Efficiency, Kg/ ha .mm
D_1	87782.37	1179.64	74.415
D_2	81349.78	1179.64	68.962
D_3	90715.33	1179.64	76.901
D_4	78183.24	1179.64	66.277

Cost of Irrigation

The cost of systems was estimated according to material quantity required for designed lay out for 1 hectare square field under different geometry drip irrigation system. The cost of trench digging/refilling for main/submain was also taken into account. The fix cost of drip irrigation system was calculated considering the 10 years life of system serving for season and 9% rate of interest. The cost of drip irrigation system was found and shown in Table 2.

Table: 6 Cost of Drip Irrigation System

Sr No.	Treatment Specifications	Fix cost	
		Rs/ha	Rs/ha/season
1	Circular pattern	146423.1	29055.38
2	Single lateral 2X 4lph	78149.36	16083.38
3	Star emitter	84935.02	17372.65
4	Single lateral 1 X8lph	69439.91	14428.58

Cost of the system varies with the geometry because of varying length of lateral requirement. Highest cost of irrigation system was found in circular geometry (Treatment D_1) of lateral. In circular geometry lateral length increased due to circular ring and also due to higher number of emitters. Single lateral with single emitter (Treatment D_4) has lowest cost as compare to other system because no any additional length of lateral was required. The cost of star emitter (Treatment D_3) is little bit higher than the treatment D_4 and treatment D_2 because of additional requirement of length of lateral and submain. Cost of single lateral with two emitter (Treatment D_2) higher than D_4 due to increased numbers of emitter.

SUMMARY AND CONCLUSIONS

Bananas are the fourth most important food crop in the world after rice, wheat and maize (Salvador *et al*., 2007). Banana has been known as a plant with a rapid growth rate, high consumption of water, shallow and spreading root distribution, roots with weak penetration strength into the soil, poor ability to withdraw water from soil which is drying (Hedge, 1988), low resistance to drought and rapid physiological response to soil water deficit (Robinson, 1995).

Earlier flowering, thicker girth, earlier harvesting time, more number of leaves, higher weight of bunch, higher yield per hectare and more number of fingers have been observed in irrigating with star emitter. Star emitter and circular geometry configurations system found to be better than single lateral with either two drippers or single dripper of 8 lph for attaining sound morphological parameters and yield attributes.

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